ATTACHMENT 7

316(B) Document For Scattergood, Haynes, And Harbor Generating Stations, 1997. Prepared For LADWP By MBC Applied Environmental Science

316(b) DOCUMENT FOR SCATTERGOOD, HAYNES, AND HARBOR GENERATING STATIONS

Prepared for:

LOS ANGELES DEPARTMENT WATER AND POWER

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April 1997

Errata & Commentary for 316(b)
Update Document Dated April 1997

Based on discussions between Mr. Robert D. Castro and Mr. Charles Mitchell, Chairman, MBC Applied Environmental Sciences on 8/5/1997, the following changes or clarifications are added to this document.

- Page 2-4, paragraph 1, sentence 2. The word turbidity and the period (.) following it should be removed.
- Page 2-54, paragraph 2, sentence 5. The source waters are defined in this paragraph as waters within 14m of the intake. The 14m point is the first point where there is no measurable flow into the intake (i.e., at that point the background noise overtakes the measurable flow). This definition of source water is markedly different from the projected source water used in table 2.10 on page 2-55. The projected source water volume is that volume of water needed so that the take of the specified specie due to entrainment is limited to 5% (the relevance of this number is explained in the next bullet item). For example, the projected source water volume needed to crop the Arcatia population by 5% is 806 Mm^3. Since this number is less than the volume of the Santa Monica Bay, the cropping of Scattergood Generating Station falls below the 5% delineation.
- Page 2-54, paragraph 4, sentence 1. The 5% mortality entrainment delineation first appeared in an EPRI document. This document, discussed in the 1981 316(b) study, cited an EPA statement in a court document as to 5% being an acceptable loss.
- Page 3-19, paragraph 2. Of the critical species discussed in the 1981 study only anchovy fish egg losses were discussed. Since no additional fish egg studies were addressed in the update document, only anchovy eggs were discussed here.
- Page 3-20, table 3-3. Of the critical species discussed in the 1981 study only the impingement of queenfish and shiner perch were discussed. Since this table is shown to be based on that data, no additional specie were added.
- Page 4-15, paragraph 6. The critical species were chosen to represent a good cross section of the different trophic levels in the Santa Monica Bay. In addition, they had to meet one of the following criteria: 1) the specie was impinged frequently or in large numbers, 2) the specie was a commercial or recreational specie (e.g., white sea bass, halibut).

- Page 4-16, paragraph 9, sentence 1. HEP is an acronym for Harbors Environmental Projects, and is a U.S. Army Corps document dating from 1976. HEP was originally used in the 1981 study and was defined only in its bibliography.
- Page 4-18, tables 4.1 & 4.2. A comparison of the two tables shows that table 4.2 has the additional column of Adult Equivalent Losses. Table 4.1 does not have this column because the species examined there are zooplankton whose life cycle is measured in weeks (in fact only the cancer and callianassa, a crab and shrimp specie respectively, are not microlife spending their lifetime living in plankton.). These species have enormous powers of recuperation from the take process. However, the ichthyoplankton of table 4.2 have lifecycles measured in years. A taking of one of these species has a much greater relativistic impact. For example, an anchovy female carries approximately 50K eggs with her in the springtime. If this anchovy is taken, the loss would not only be the 50K eggs she is carrying, but, since she could conceivably breed four more years, an additional 200K eggs she could potentially produce. Since ichthyoplankton typically require a much greater period to achieve reproductive age, the recuperative powers of the specie are not comparable to the zooplankton. An equivalent adult loss is a much more meaningful extrapolation for ichthyoplankton.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Federal Water Pollution Control Act Amendments of 1972, Section 316(b), concerning cooling water intakes, state that "Any standard established pursuant to Section 301 or Section 306 of the Act and applicable to a point source shall require that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact."

In response to Section 316(b), between 1978 and 1979, extensive monitoring programs were conducted at the Los Angeles Department of Water and Power's Scattergood, Haynes, and Harbor Generating Stations to determine effects of plant operation on surrounding ecosystems and local marine life. The findings of these surveys were published in three separate documents in 1981. Marine life studied included zooplankton, fish eggs, ichthyoplankton, and adult fin fish.

Since that time, permits issued under the National Pollutant Discharge Elimination System (NPDES) have set standards relating to monitoring of the marine environment in the vicinity of each generating station.

This report has compiled available data from NPDES monitoring and other sources to "update" findings and estimates of the 1981 316(b) document for the Scattergood, Haynes, and Harbor Generating Stations. Each generating station is addressed in a complete and separate chapter.

Within each chapter are six sections. The first two sections characterize the study area and the respective generating station. The third section describes the present marine biological setting of each generating station. The fourth and fifth sections are devoted to examining different physical, oceanographic and plant operating effects on marine life, assessing losses as a result of power plant operations, and discussing any differences between 1978 and 1979 and the present. The final section reviews all data to determine whether the best available technology continues to be used at the respective generating station relative to losses due to entrainment and impingement.

Scattergood Generating Station is located on the southern California coast in the city of Los Angeles. Seawater utilized in the once-through cooling system is withdrawn from Santa Monica Bay through a submerged intake structure located approximately 488 meters from shore at a depth of about 8.65 meters mean sea level (MSL). Seawater flow is first directed horizontally to the inlet conduit by a 9.9-meter diameter velocity cap, then is carried from the intake structure through an underground conduit a distance of 608 meters to the generating station. After passing through the plant, the cooling water is discharged into Santa Monica Bay approximately 122 meters shoreward of the intake structure. Design maximum cooling water flow is approximately 495 million gallons per day (mgd).

Scattergood Generating Station consists of three fossil-fueled steam-electric generating units. Total plant capacity is 830 megawatts (Mw). Units 1 and 2, on line since 1958-1959, have a rated capacity of 185 Mw each. Unit 3, on line since 1974, has a capacity of 460 Mw. Steam is supplied to each turbo-generating unit from a separate boiler. Units 1 and 2 may be fired by either natural gas or fuel oil; Unit 3 can be fired only by natural gas.

Haynes Generating Station is located near the southern California coast in the city of Long Beach. Cooling water is withdrawn from Alamitos Bay through an intake structure situated in the bulkhead of the Long Beach Marina. After passing through the plant, the effluent is discharged into the San Gabriel Flood Control Channel, which empties into San Pedro Bay. Each pair of the six generating units has a discharge structure located in the San Gabriel Channel. Alamitos Generating Station (operated by the Southern California Edison Company) also uses the San Gabriel Channel for the discharge of once-through cooling water. Combined maximum cooling water flow is approximately 1,014 mgd.

Haynes Generating Station consists of six steam electric generating units. The six units were sequentially brought on-line beginning with Unit 1 in 1962 and ending with Unit 6 in 1967. Units 1-4 have a rated capacity of 230 Mw each and Units 5 and 6 each have a rated capacity of 343 Mw. Steam is supplied to each turbo-generating unit from a separate boiler capable of being fired by either fuel oil or natural gas. Total net capacity of the generating station is 1,451 Mw when fired by gas and 1,583 Mw when fired by oil.

The Harbor Generating Station is located in the Inner Los Angeles Harbor complex. Cooling water is drawn from Slip 5, southeast of the plant, and discharged into the West Basin. All units at the Harbor Generating Station share a common cooling water intake system. Water is drawn from the northwest corner of Slip No. 5 through a 17.1-meter wide by 3.1-meter high intake structure from an approximate depth of 3.4 to 6.4 meters below Mean Lower Low Water (MLLW). After passage through the plant, the water is conveyed through two eight-foot diameter underground conduits approximately 490 m to a submerged multiport discharge structure located in the pierhead near the northeast corner of the West Basin of the Los Angeles Harbor. Average maximum flow through the station is approximately 391 mgd.

Harbor Generating Station originally consisted of five steam electric units. The first unit was brought on-line in 1943 with subsequent units added until the fifth and final unit was placed into operation in 1949. Unit 1 had a capacity of 72 Mw. Unit 2 had a capacity of 67 Mw, and Units 3, 4, and 5 had a capacity of 86 Mw each. Total steam generating capacity was 398 Mw until 1991. At that time, Units 1 and 2 were decommissioned and removed, lowering total plant capacity to 258 Mw. In October 1991, Units 3, 4, and 5 were deactivated for plant upgrades which were not completed until the latter part of 1993.

The purpose of this study is to update data and information contained in the 1981 316(b) documents with information obtained since then, and evaluate where possible what effects, if any, the operation of Scattergood, Haynes, and Harbor Generating Stations are having on surrounding ecosystems and marine populations. Monitoring programs implemented at each of the generating stations for the original 316(b) demonstration had many similar components.

During the 1981 demonstration, much time and effort was put into ascertaining losses of zooplankton, fish eggs, and fish larvae due to entrainment, and adult fish losses due to entrainment and impingement. The first step was the development of a critical species list to narrow the focus of each study. The list of critical species for impinged fishes in the 1981 demonstration contained five species. For the present study this list was expanded to include seventeen species to better characterize impingement losses and source water populations. With the exception of California corbina, all of the 1981 species were included in the present study. Critical species of zooplankton, fish eggs, and fish larvae discussed in the present study are the same critical taxa from the first 316(b) survey for all three generating stations. The seventeen critical species for Scattergood Generating Station include the fifteen most abundant, and frequently impinged species, as well as white seabass and California halibut. For Harbor and Haynes Generating Stations, the critical species discussed were those chosen for the original 316(b) surveys at each of the generating stations, since no more recent impingement data are available.

The effects of entrainment on plankton (zooplankton, fish eggs, and fish larvae) were well studied during the original 316(b) surveys. Sampling at far-field stations, as well as at the intake structures, gave scientists a chance to assess the composition and densities of "resident" plankton populations in source waters, and compare that with what was being affected by the intake structures of the three generating stations. Since the majority of the plankton organisms are transported passively (their distribution is dependent on prevailing currents), the entrainment of these organisms is more directly related to intake flow than the impingement of fish, which can attempt to counteract currents. This report reviews the results of plankton surveys from the original 316(b) documents, and speculates how entrainment losses might differ at present due to operational differences. Plankton mortality estimates due to entrainment at Harbor Generating Station for the 1981 316(b) survey were made using through-plant mortality data collected for the Haynes 316(b) survey, since the plankton communities are almost identical.

Loss of adult fin fish through impingement has been monitored regularly since late 1989 at Scattergood Generating Station. These data have been compared with estimates of annual nekton mortality from the Scattergood 1981 316(b) study, and wave height, sea temperature, flow, and weather data, as well as period between heat treatments to see if any correlations exist between these variables and fish impingement at Scattergood Generating Station.

Loss of adult fin fish through impingement has not been regularly monitored at Haynes Generating Station or Harbor Generating Station.

In conclusion, the following results were obtained:

Zooplankton, Fish Eggs, and Fish Larvae

1) Losses of entrained organisms were the result of predation and grazing by the biofouling community and nekton, as well as stresses created by the generating stations.

2) While entrainment mortality rates were high, the loss to the source water populations were extremely low and considered insignificant.

Fin Fish

1) Impinged fish losses reported in 1981 were minimal at the Harbor and Haynes Generating Stations. While fish impingement has not been regularly monitored since the original 316(b) survey (since neither local fish populations nor the operational configuration of these facilities have changed), fish losses are not considered to be significant.

2) Fish loss at Scattergood Generating Station has been regularly monitored since 1981. Average heat treatment biomass since 1989 has been 866 pounds. On average, for the period 1989 to 1995, the Scattergood Generating Station produced an annual loss of 4,329 pounds.

3) The most abundant fish impinged was jack mackerel, followed by queenfish, topsmelt, jacksmelt, and northern anchovy, a pattern similar to that reported in 1981.

4) No commercially important or recreationally important fish populations were adversely impacted or threatened due to operation of the Scattergood Generating Station.

5) The present intake configurations at the Scattergood, Haynes, and Harbor Generating Stations and resulting biological findings indicate minimal adverse environmental effects from the operation of the three generating stations. Alternate technologies are not discussed in reference to any of the generating stations because existing intake systems appear to reflect the best demonstrable technology available to reduce entrainment and impingement losses.

CHAPTER 1
INTRODUCTION

INTRODUCTION

The Federal Water Pollution Control Act Amendments of 1972, Section 316(b), concerning thermal discharges, state that "Any standard established pursuant to Section 301 or Section 306 of the Act and applicable to a point source shall require that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact."

Pursuant to Section 316(b), intensive monitoring programs were enacted at the Los Angeles Department of Water and Power's Scattergood, Haynes, and Harbor Generating Stations. Data were collected in 1978 and 1979. The purpose of these studies was to determine (quantitatively and qualitatively) effects on marine life from the operation of the generating stations. In 1981, a report was generated for each generating station which described methods and findings of the 316(b) demonstration.

Since these surveys, monitoring programs at the Scattergood, Haynes, and Harbor Generating Stations has followed guidelines set forth in NPDES permits for each station; the scope of the monitoring programs has varied between 1981 and 1995. Locations of the generating stations are shown in Figure 1.1. For Scattergood Generating Station, monitoring has included demersal fish surveys, fish loss monitoring during heat treatment operations, monitoring physical and chemical water quality parameters, sediment grain size analysis, sediment chemistry analysis, contaminant bioaccumulation surveys, and benthic infaunal sampling. Monitoring programs for Scattergood Generating Station and El Segundo Generating Station (a steam generation plant located directly downcoast from Scattergood) have been consolidated since they operate in such close proximity to one another.

The original 316(b) demonstrations extrapolated data from the one-year monitoring programs to estimate annual entrainment and impingement losses. This survey will use available data to update information contained in the original 1981 316(b) documents. Additional data include NPDES monitoring data from Scattergood Generating Station and the Hyperion Treatment Plant, operating characteristics of the Scattergood Generating Station, ichthyoplankton monitoring data from Marina del Rey, demersal fish data from the Southern California Bight Pilot Project, sport fish catch data from Santa Monica Bay, and Catch Block information from the California Department of Fish and Game. Sea temperature and weather data were obtained from Los Angeles County Lifeguards.

Figure 1.1. Location of Scattergood, Haynes, and Harbor Generating Stations (IRC 1981a).

CHAPTER 2
SCATTERGOOD GENERATING STATION

SCATTERGOOD GENERATING STATION

CHARACTER OF THE STUDY AREA

Santa Monica Bay is an open embayment on the southern California coast just west of Los Angeles, with natural boundaries extending from Point Dume to Palos Verdes Point. Offshore, water depths reach about 503 m. Santa Monica Bay is a relatively small feature in a larger geographic region [the Southern California Continental Borderland (Emery 1960, SCCWRP 1973)] – the offshore, submerged lands from Point Conception, California to Cape Colnett, Baja California and seaward to the Patton Escarpment. Without the geological connotation, this region is known more commonly as the Southern California Bight, the seaward boundary of which is the California Current. For the purposes of this study, source waters of the Scattergood Generating Station will include those waters in Santa Monica Bay extending from Point Dume to Palos Verde Point, from shore to the 27 m (90 ft) depth contour.

Santa Monica Bay is one of the most well-studied bodies of water on the west coast of the United States. Under sponsorship by the United States Environmental Protection Agency (EPA), State Water Resources Control Board (SWRCB), and State Environmental Affairs Agency (SEAA), the Santa Monica Bay Restoration Project (SMBRP) was established to meet goals outlined in the National Estuary Plan (NEP). A Management Conference was established to overview the activities of the Project and is being conducted by a Management Committee composed of representatives of 54 organizations, including Santa Monica Bay-area Congressional and State legislative representatives, cities bordering Santa Monica Bay, Los Angeles County, regulatory and resource agencies, major dischargers, environmental and industry groups, and public interest groups.

In addition to the Los Angeles Department of Water and Power's Scattergood Generating Station, several other industrial dischargers utilize Santa Monica Bay. Southern California Edison's El Segundo and Redondo Generating Stations circulate up to 1,800 million gallons of seawater per day. Chevron USA discharges small amounts of treated effluent into Santa Monica Bay, and uses the bay to transport crude oil and refined petroleum products to and from its El Segundo refinery. Hyperion Treatment Plant (located immediately upcoast of the Scattergood Generating Station) discharges treated municipal wastewater at a distance of approximately 8 km offshore, relying on ocean water to dilute primary- and secondary-treated effluent. Los Angeles County Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) discharges approximately 325 mgd of treated municipal wastewater onto the Palos Verdes Shelf. The JWPCP discharges a mixture of 60% secondary- and 40% advanced primary-treated wastewater through two outfalls.

The physical characteristics of the Santa Monica Bay ecosystem are determined primarily by the geology, climate, and oceanography of the region. Geological features provide the framework for the system within which climate and oceanography determine many natural environmental cycles.

Offshore of the Los Angeles Basin is the Santa Monica Basin, which is a downthrown block that has only been partially filled with eroded sediments; hence, it is still a fairly deep marine basin. The shelf in Santa Monica Bay is partly the sediment-filled Los Angeles Basin and partly the sill that separates the Los Angeles and Santa Monica Basins. Bedrock lies much nearer the sediment surface beneath the sill than beneath the two basins (Emery 1960).

Topography of Santa Monica Bay

Santa Monica Bay is characterized by a gently sloping (about 0.5°) shelf, which extends seaward to the shelf break at a water depth of about 80 m (Terry et al. 1956). At the break, the seafloor steepens along the slope, but decreases again as the floor of the Santa Monica Basin is approached at a water depth of about 802 m.

The shelf in the bay ranges in width from a few hundred meters to about 19 km (Figure 2.1). It is broadest off El Segundo, narrowest off Redondo Beach, and is transected by three submarine canyons: Dume Submarine Canyon across the northwestern shelf off Point Dume; Santa Monica Submarine Canyon 11 km offshore of Ballona Creek, and Redondo Submarine Canyon a few hundred meters off King Harbor. In this report, the region between Santa Monica and Point Dume is called the Malibu Shelf, and the region between the Ventura-Los Angeles County Line and Point Dume is called the Carillo Shelf.

The bottom type of the seafloor is largely a function of the water movement in the overlying water mass, although the proximity of the sediment source can be important. Coarse sand and gravel are found under swiftly moving water, whereas fine silt and clay settle to the bottom in less turbulent water. In most parts of Santa Monica Bay the seafloor consists primarily of fine to moderately coarse, unconsolidated sediments. However, hard bottoms of bedrock, gravel, and phosphorite are found in some areas (Figure 2.2).

Small patches of relict red sand are found on the central plateau and south of Redondo Canyon (Terry et al. 1956). Relict sands were deposited at lower sea level stands, representing ancient beaches or sand dunes that have been re-exposed by currents.

Exposed bedrock is found nearshore along the Carillo and Malibu coasts, from the Ventura-Los Angeles County line to Pulga Canyon, and from Malaga Cove to Point Fermin on the Palos Verdes Shelf. Exposed bedrock is also found offshore, on the central shelf (Short Bank) of the Santa Monica Shelf, and in both Santa Monica and Redondo Submarine Canyons.

Anthropogenic hard-bottom substrates in the study area include municipal wastewater outfall pipes (three from Hyperion Treatment Plant, and four from the Joint Water Pollution Control Plant), as well as smaller outfall structures for generating stations and the Chevron refinery. Other artificial hard-bottom structures include jetties, breakwaters, groins, and artificial reefs.

Because subtidal, hard-bottom habitats support algal growth and attract sportfisheries species, the California Department of Fish and Game (CDFG) has constructed 14 artificial reefs in Santa Monica Bay since 1958. The first five were constructed of degradable materials (streetcars and automobiles) and have since disappeared. Nine artificial reefs (constructed since 1962 out of quarry rock, concrete, pier pilings, tires, and marine vessels) are expected to remain for much longer (Lewis and McKee 1989).

Climate

Air Temperature

The climate of southern California is Mediterranean, characterized by warm, dry summers and mild, wet winters. Although fewer than half of the days of the year are cloudy, insolation (i.e., sunshine) is greatest from March to September. The sun heats the air, land, and water; in turn, the land and water heat the air. The average daily (24-hr) air temperature in the study area ranges from 45 to 72°F annually (SCCWRP 1973), being coldest in January and warmest in July.

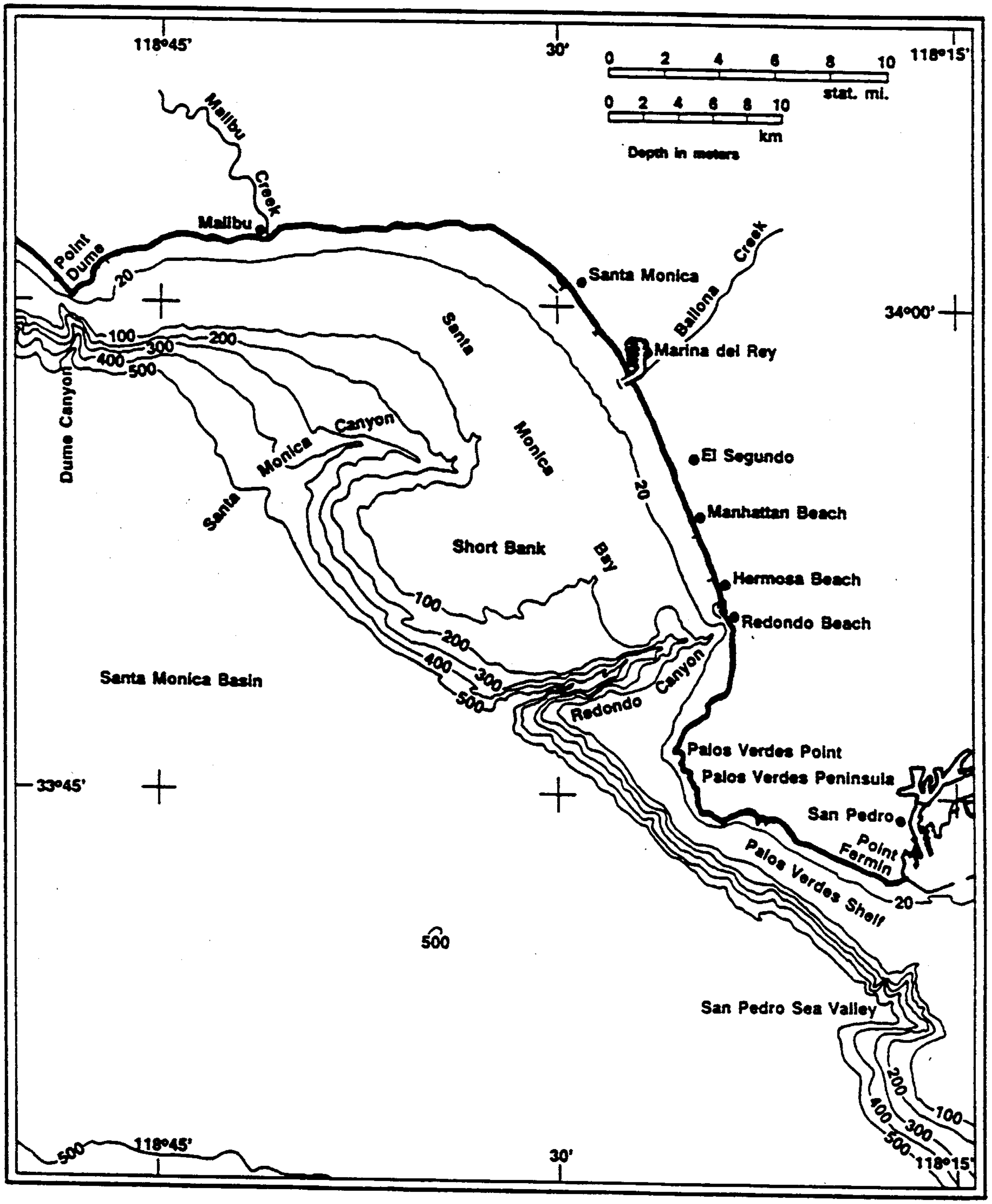

Figure 2.1. Topography of Santa Monica Bay (MBC 1988a).

Rainfall

The average annual rainfall on the Coastal Plain is 12 to 13 in., about 90% of which occurs between November and April (SCCWRP 1973, Kimura 1974, Miller and Hyslop 1983). In winter, cold-front storms typically come from the northwest; in summer, tropical storms called "chubascos" occasionally come from the southeast.

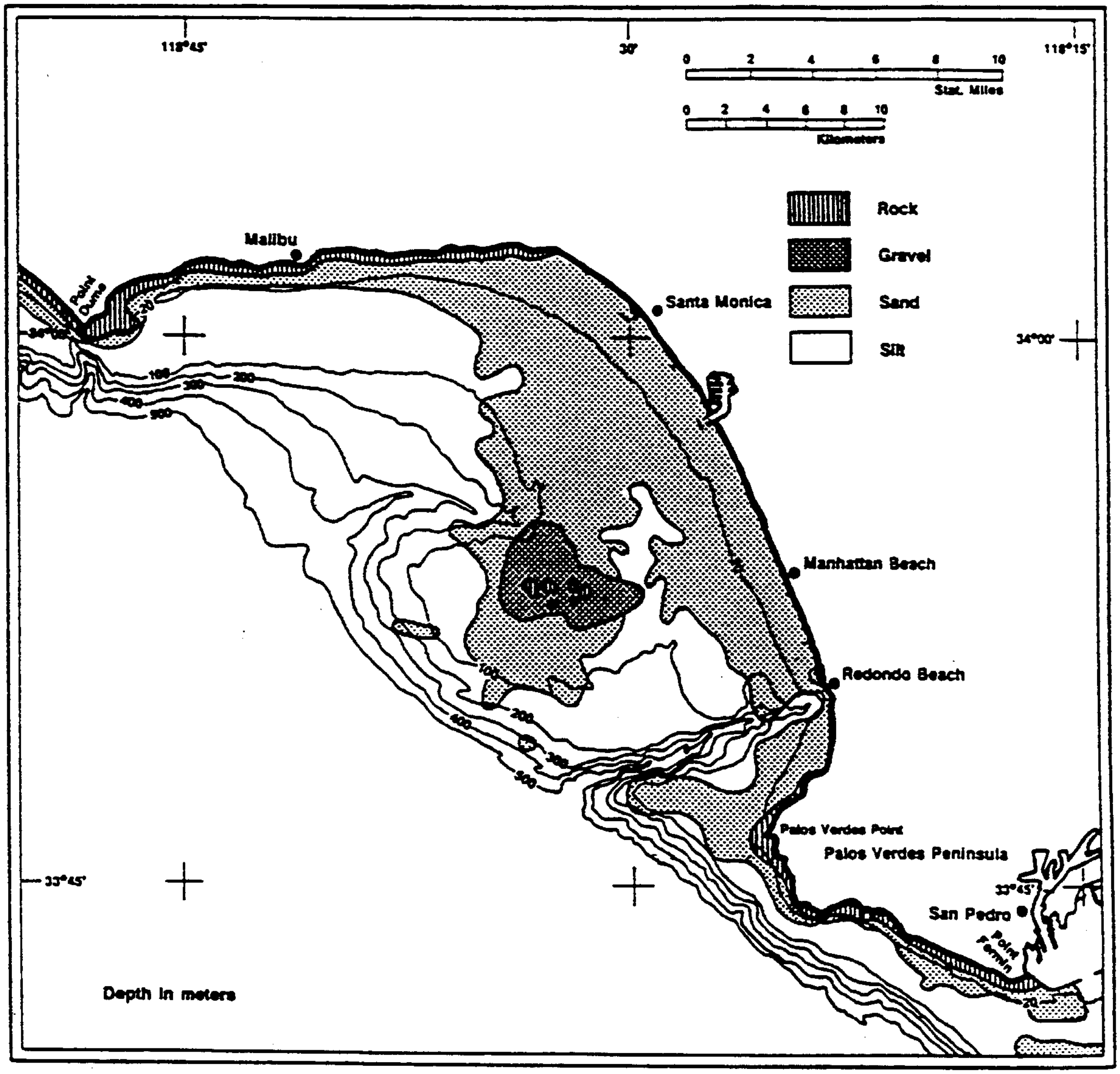

Figure 2.2. Bottom types of Santa Monica Bay (MBC 1988a).

Wind

Prevailing winds along the coast are from the west-northwest and wind speed is generally low throughout the year. In summer, sea breezes typically blow onshore in the morning as air over the land heats up, rises, and pulls cool air from the ocean (Miller and Hyslop 1983). At night, offshore land breezes often develop as air over the land is pulled seaward, while air over the warmer ocean rises. During winter (but occasionally at other times), hot, dry Santa Ana winds blow to the west off the deserts east of the Los Angeles Basin. These gusty winds result from high pressure cells over the desert and enter the coastal zone through mountain passes.

El Niño Events

Every so often, with a quasiperiodicity of three to five years (Graham and White 1988), the oceanic environment of southern California changes dramatically as an El Niño Southern Oscillation event takes place. During an El Niño, the normal water mass off the California coast is replaced by water which is warmer, more saline, and lower in nutrients than usual. These conditions extend through the water column and may persist for months or years.

El Niños result from large-scale changes in the climate and oceanography of the Pacific Ocean as a whole. Normally, tradewinds north of the Equator, which blow to the west, force water to accumulate in the western Pacific. When tradewinds weaken, seawater flows easterly (as a long-period wave), and moves both north and south along the coast when it hits the Americas. Because currents in the North Pacific also decrease in strength, the south-flowing California Current is weakened, and the warm-water mass from equatorial latitudes penetrates into the Southern California Bight. The most recent large El Niño event was in 1982-1983, with the previous large El Niño in 1957-1959. Events of lesser magnitude occurred in 1986-1987 and in 1991-1992 (Radovich 1961, Graham and White 1988, Kerr 1992, Tegner et al. 1995).

During an El Niño, marine organisms with more southern distributions occur in the Bight whereas cold water species migrate northward or to deeper waters: pelagic red crabs which are normally found off southern Baja California were abundant offshore southern California in 1982 and 1983.

El Niño periods are also frequently characterized by stronger-than-normal winter storms, accompanied by large waves which destroy coastal structures, erode beaches, and churn up the nearshore environment. Sediment carried by terrestrial runoff and suspended by wave activity can persist along the coast, reducing visibility and algal and phytoplankton growth. Reduced nutrient levels accompanying an El Niño can result in a decline in kelp beds (Tegner et al. 1995, Dailey et al. 1993), decreasing habitat available to fish communities dependant on the kelp.

Oceanography

Oceanographic conditions in the study area are largely a function of the California Current and other offshore currents, as modified by local topography and conditions.

Currents

The California Current is a low-temperature, low-salinity, and nutrient-rich current that flows south along the California coast (Figure 2.3). It varies in velocity from year-to-year, but is usually strongest in late summer (Dailey et al. 1993). South of Point Conception, the California Current generally flows along the Patton Escarpment (160 km offshore), and approaches the coast again near Cape Colnett, Baja California.

Off Baja California, part of the California Current flows north into the Southern California Bight as the Southern California Countercurrent. Part of this countercurrent exits the Bight through the Santa Barbara Channel and rejoins the California Current (Dailey et al. 1993). Beneath the surface water mass (to depths of approximately 250 m) is a relatively high-temperature and high-salinity current called the California Undercurrent, which flows to the north (CLA, DPW and USEPA 1977; Jackson 1986), and surfaces nearshore north of Point Conception during the fall and winter, and is known then as the Davidson Current.

Local currents are affected by local submarine topography, winds, and tides, and are of two kinds: longshore currents, which flow parallel to shore and cross-shore currents which move perpendicular to shore. Longshore currents are fastest near the surface; near-bottom they are slowed by seafloor friction. Off Palos Verdes and the seaward edge of Santa Monica Bay, longshore currents flow north at approximately 0.05 m per second (CLA,DPW and USEPA 1977).

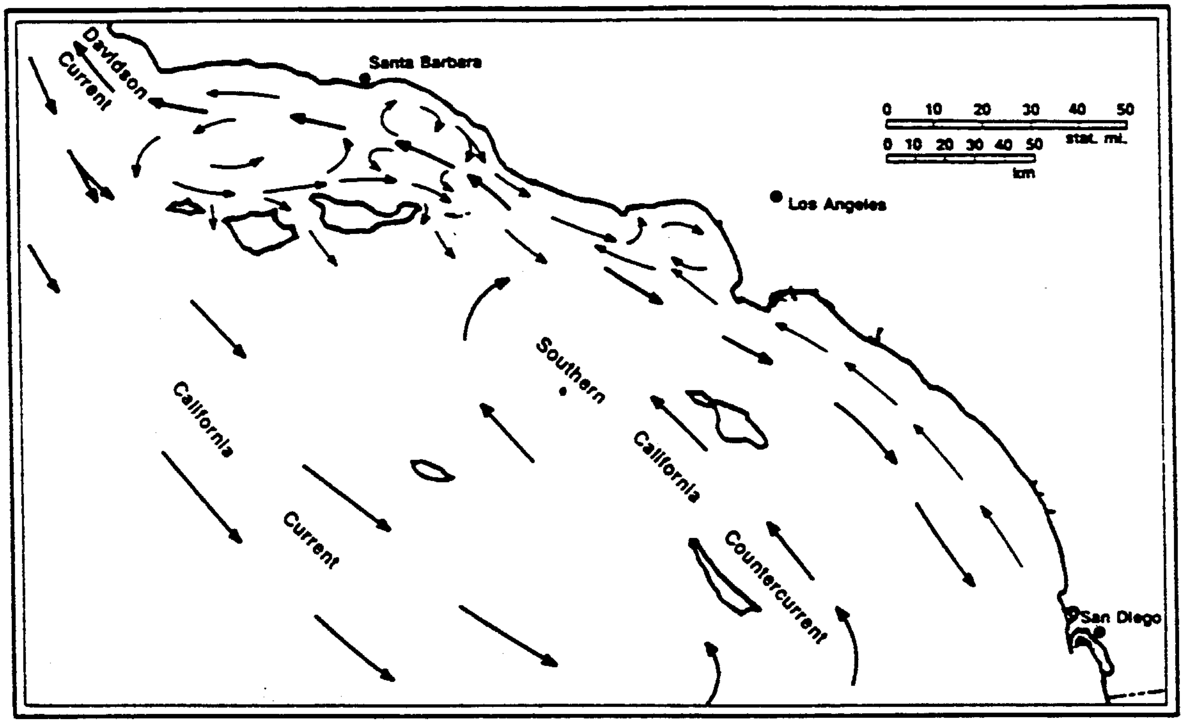

Figure 2.3. General ocean circulation in the Southern California Bight (MBC 1988a).

However, surface currents, with speeds up to 0.6 m per second for several days, have been measured on the Palos Verdes Shelf (SDWG 1988). Cross-shore currents flow shoreward or seaward near the surface and at depth; they are generally caused by surface wind forcing or by internal waves (Jackson 1986).

Surface currents in Santa Monica Bay are complex. Below the upper 30 m, currents flow north (MBC 1988a). Recent studies suggest that a clockwise gyre dominates on the shelf, except when it reverses for a few days at a time and inshore of the 21-m isobath due to tidal action. The residence time of surface water (0-90 m) in the bay is estimated to be three to four days.

Littoral currents move alongshore and adjacent to the shore, and are caused by breaking waves, as modified by shore topography. The littoral currents may move as much as 2.4 m per second and often transport beach sediments in a turbid layer, which is denser than seawater and which may flow into submarine canyons as turbidity currents (Drake and Gorsline 1973).

Current flow off of Scattergood Generating Station is mainly longshore with an onshore component, with winds and tides being the driving forces. Current directional frequencies from two stations (320 m south and 20 m north of the intake), sampled for approximately six months during 1978-1979, indicate mainly longshore current movement (Figure 2.4) (IRC 1981a). Tidal currents contribute significantly to ambient velocities, resulting in a change in direction of longshore travel approximately every 6.24 hrs (IRC 1981a). Ambient current speed changes more or less sinusoidally over the tidal cycle. Hourly averaged speeds of less than 0.01 m per second typically occur less than 10% of the time. Current speeds between 0.01 and 0.06 m per second occur about 55% of the time. Maximum speeds are typically about 0.2 m per second.

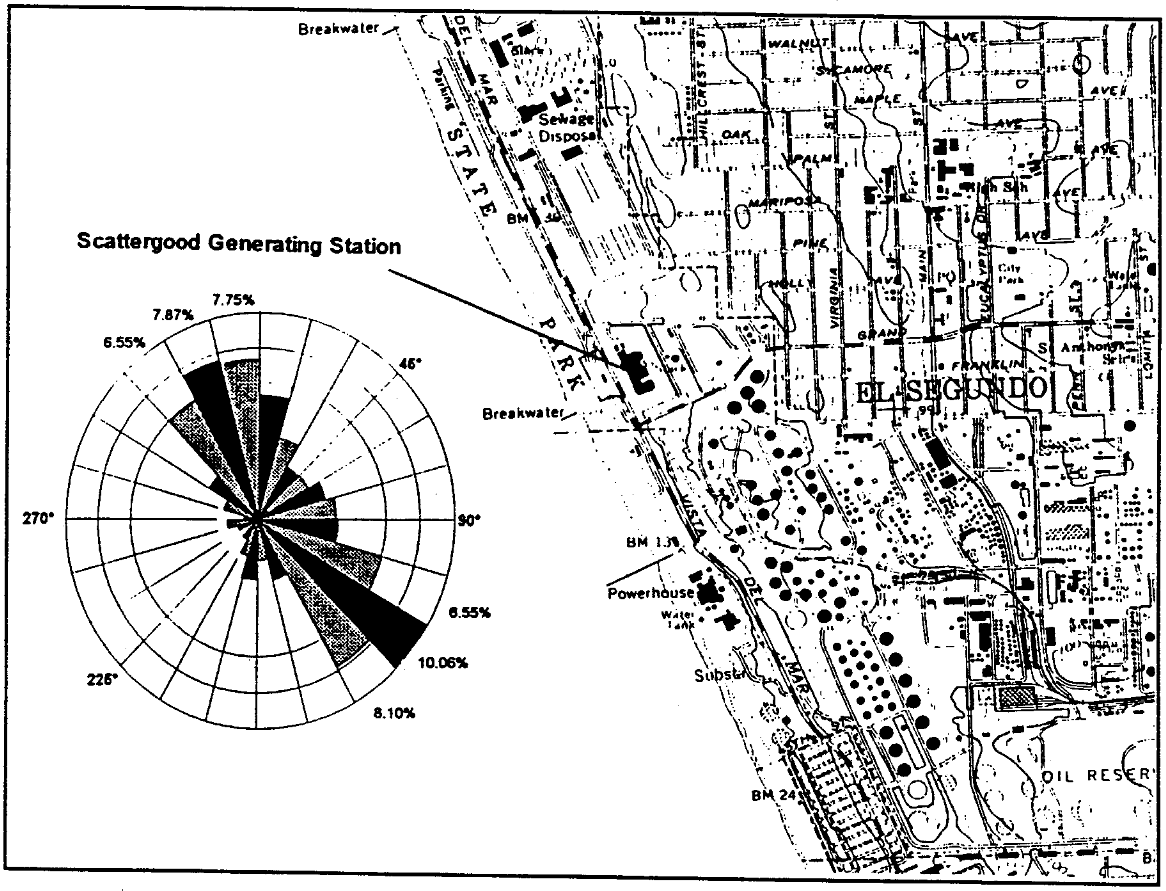

Figure 2.4. Current directional frequencies offshore Scattergood Generating Station (IRC 1981a).

Tides

Southern California has a mixed, semidiurnal tide, which is composed of two unequal high tides and two unequal low tides every 24 hr 50 min. In Santa Monica Bay, the high and low tides generally differ by 1.1 m, although spring tides may differ by 1.7 m (NOS 1986). In the eastern North Pacific Ocean, the tide wave rotates in a counterclockwise direction. As a result, tidal currents tend to flow onshore and upcoast during flood tide, and offshore and downcoast during ebb tide.

Waves

Point Dume and the offshore islands shelter much of Santa Monica Bay from most westerly and northerly storms. Typically, surf runs 3 to 4 ft along the beach at the generating station. However, long period waves from storms may generate surf 10 to 15 ft high along the coast, suspending sediments in the water column, and redistributing them at various depths. On the Palos Verdes Shelf, storm waves can resuspend sediments to depths of 45 m (SDWG 1988).

Upwelling

During prolonged northwesterly winds in winter and spring, nearshore surface water is transported offshore along coasts with a northwest-southeast orientation (Dailey et al. 1993).

Wind-induced friction causes the nearshore surface waters to begin moving offshore. Once moving, the Coriolis effect deflects water further offshore (Garrison 1993). Subsequently, nearshore waters are replaced by deep, oxygen-poor and nutrient-rich waters. This process is important because the nutrient-rich waters stimulate plankton productivity, the primary component of the marine food web. Frequently, patches of cold water in response to upwelling have occurred in Santa Monica Bay and over the San Pedro shelf, but generally occur less frequently and less intensely than in other coastal areas north of Point Conception (Dailey et al. 1993).

Characteristics of Seawater

Natural seawater is characterized by a number of physical and chemical attributes, all of which vary seasonally as well as in irregular fashion. Key characteristics are described below, especially as they may be influenced by man's activities.

Temperature

Surface temperatures in the Southern California Bight range from about 54 to 77°F (Dailey et al. 1993), with temperatures being warmest in summer (May through November), and cooling through winter (SCCWRP 1973). Near the Scattergood Generating Station intake, surface temperatures range from about 62°F in winter to 70°F in summer, and near-bottom temperatures range from 60°F in winter to 67°C in summer (OC 1987, 1989; MBC 1990a to 1995a).

Salinity

The major feature of seawater is the dissolved salts, which produce its characteristic saltiness. Salinity is measured in parts per thousand (ppt), which refers to the amount of salt it contains. Most of the salt is common table salt, sodium chloride (NaCl); abundant ions in seawater include sodium (Na^+), chloride (Cl^-), sulfate (SO_4^{2-}), magnesium (Mg^{2+}), calcium (Ca^{2+}), potassium (K^+), and bicarbonate (HCO_3^-). Chloride comprises about 55% of the ions, sodium about 30%, and sulfate about 8%. Nearshore, salinity in the Southern California Bight peaks in July at about 33.6 ppt, decreasing to about 33.4 and 33.5 in late winter and early spring (Dailey et al. 1993). The coastal waters of Santa Monica Bay are normally more saline during the summer, due to evaporation of water and less saline in winter as a result of freshwater runoff.

Density and Stratification

The density of seawater is a function of its temperature and salinity. Thus, layers of sharply different densities adjacent to one another (a pycnocline) can result from differences in temperature, salinity, or a combination of the two. Water above the pycnocline usually has little internal structure; it tends to be homogeneous and is called the mixed layer. In Santa Monica Bay, a thermocline often develops (from spring to fall) as a result of warm surface temperatures. In winter and spring, a low-salinity lens at the surface may result from stream runoff. In summer, a pycnocline occurs over the shelf at depths of about 35 ft. When the surface temperature drops in the fall, the density of the upper layer approaches that of the lower layer, and the pycnocline breaks down. The mixed layer then extends into depths of 100 ft between December and March (Jackson 1986).

Transparency to Light

The depth to which light will penetrate the ocean is dependant on numerous factors, including the absorption of light by water, the wavelength of light, transparency of the water, reflection from the water surface, suspended particles in the water column, latitude, and season of year. Water transparency (as measured by a standard Secchi disk) generally ranges from 6 to 15 m in southern California, with the lowest values occurring close to shore. A band of low transparency water is characteristic within about 1.6 km of the shore.

Light penetration is especially important to photosynthesis. Most photosynthesis occurs in the mixed layer, from the surface to water depths of about 11 m (MBC 1993b). This area is referred to as the photic zone. As light levels decrease, photosynthesis decreases. The lower boundary of the photic zone is referred to as the compensation depth; no net photosynthesis occurs here. Sunlight intersects the sea surface at a steeper angle in summer than in winter; thus, light penetrates more deeply in summer and the photic zone is deeper. Transparencies are generally lower during spring than during fall, probably due to an increase in freshwater runoff from land (SCCWRP 1973).

Hydrogen Ion Content (pH)

The pH of seawater over the coastal shelf ranges from 7.5 to 8.6. High values result from photosynthesis, which removes CO_2 from the water. Because photosynthesis decreases and net respiration increases with depth, CO_2 increases and, hence, pH decreases with depth (CLA, DPW and USEPA 1977).

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Southern California Bight vary greatly with depth. Surface DO values are generally high as a result of photosynthetic activity and diffusion from the atmosphere. Values tend to decrease as distance from the surface increases, and photosynthesis ceases, and decomposition of organic material increases. In shallow, well-mixed water, DO may increase with depth as temperature decreases, reflecting the solubility of oxygen in seawater. The solubility of gases in seawater is a function of temperature; the lower the water temperature, the greater the solubility (Nybakken 1988).

GENERATING STATION DESCRIPTION

Location

Scattergood Generating Station is located on the southern California coast in the city of Los Angeles (Figure 2.5). Seawater, utilized in the once-through cooling system, is withdrawn from Santa Monica Bay through a submerged intake structure located approximately 488 m from shore at a depth of about 8.65 m MSL (Figure 2.6). Intake structures for Southern California Edison Company's El Segundo Generating Station are located about 1,067 m downcoast of the Scattergood intake.

Station Description

Scattergood Generating Station consists of three fossil-fueled steam-electric generating units. Total plant capacity is 830 MW. Units 1 and 2, on line since 1958-1959, have a rated capacity of 185 MW each. Unit 3, on-line since 1974, has a capacity of 460 Mw.

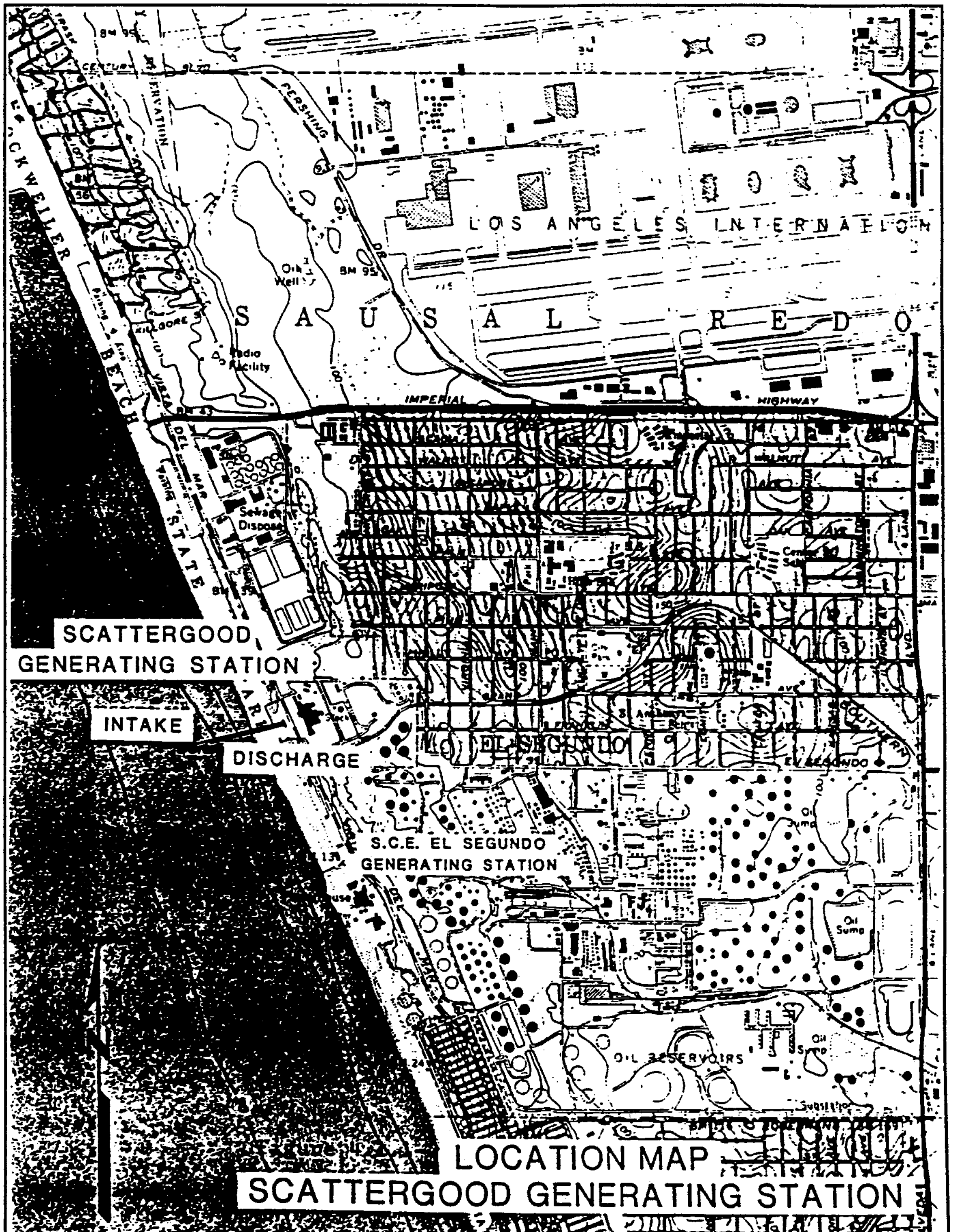

Figure 2.5. Location of Scattergood Generating Station (IRC 1981a).

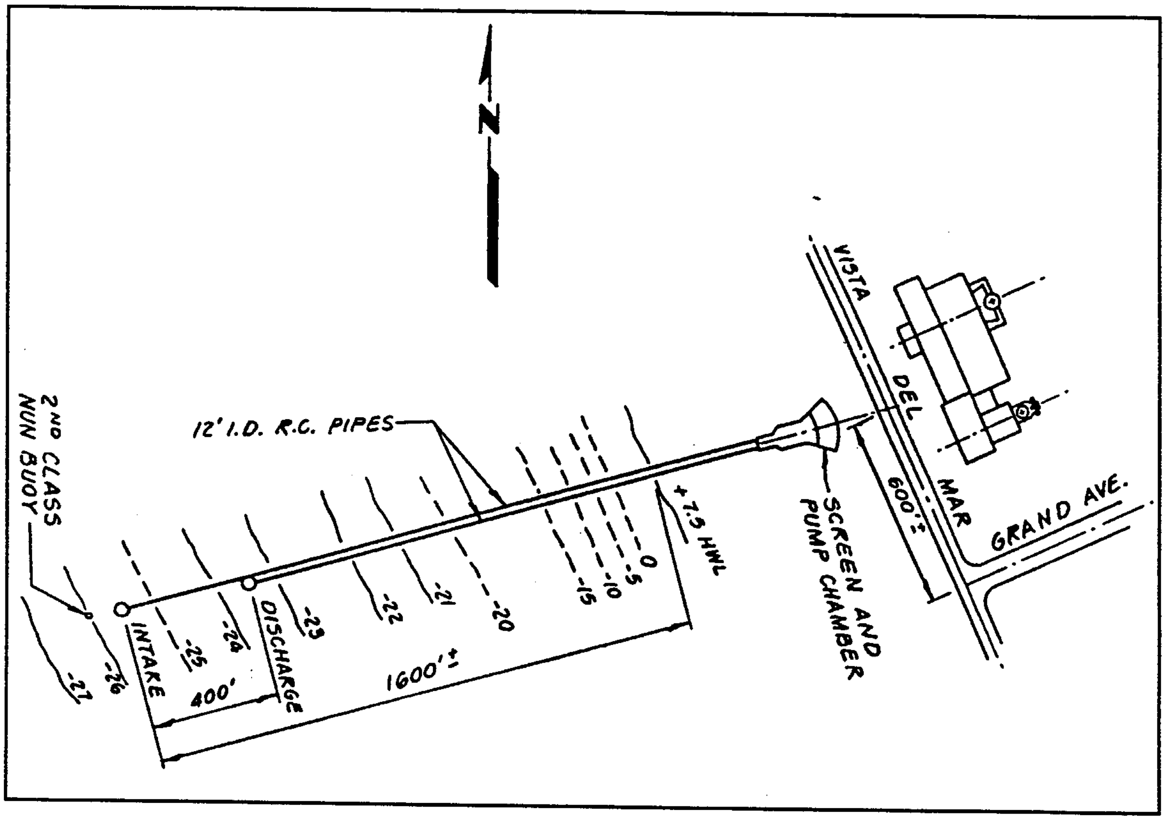

Figure 2.6. Scattergood Generating Station intake and discharge lines (IRC 1981a).

Steam is supplied to each turbo-generating unit from a separate boiler. Units 1 and 2 may be fired by either natural gas or fuel oil. Unit 3 can be fired only by natural gas. Design life of these units is 30 years.

Cooling Water System Description

Cooling water is withdrawn from the intake structure, which is located 488 m offshore in approximately 9 m of water. The seawater flow is first directed horizontally to the inlet conduit by a 9.9-m diameter velocity cap, which is suspended 1.5 m above a vertical riser; the opening of which, at about mid-depth, is at 5.3 m (Figure 2.7). The outside diameter of the riser is the same as the velocity cap. Design approach velocity is 0.46 m/s at the rim of the cap. The water enters the system through the 5.3-m inside-diameter (ID) vertical riser, and is conveyed through a single 3.66-m ID underground conduit to the generating station, an additional 152 m inland from the shore. Maximum velocity inside the conduit is 2.07 m/s.

Rock riprap protects the intake structure. The original riprap, composed of large boulders, did not provide sufficient protection to the structure, so in 1980, new riprap, composed of smaller rocks of differing sizes, was positioned at the intake to reduce sand loss, provide a flexible mat, and to reduce the interstitial spaces. It was thought that elimination of large spaces in the riprap would reduce the preferential habitat and, therefore, the number of fish in the immediate area of the intake.

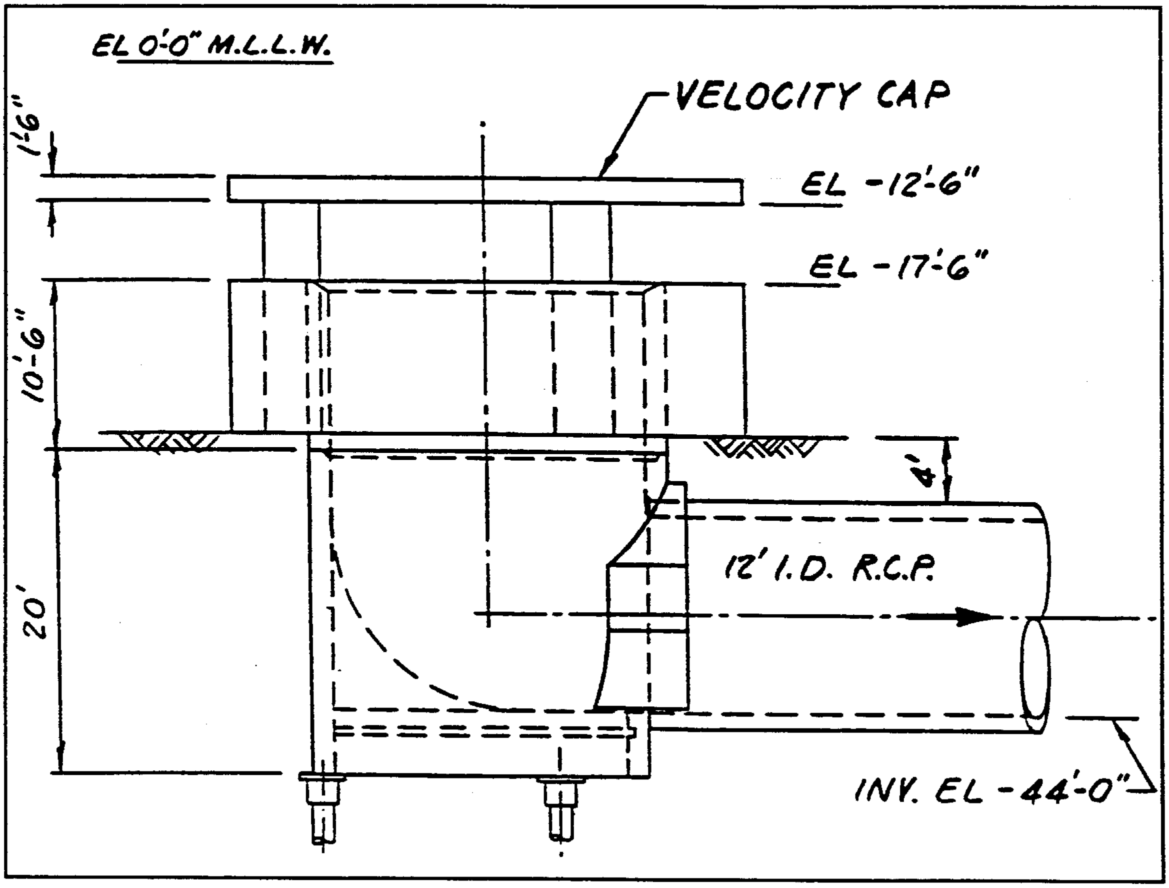

Figure 2.7. Scattergood Generating Station intake riser and velocity cap (IRC 1981a).

The seawater is conveyed to a vertical-walled screen and pump chamber on the seaward side of the generating station (Figure 2.8). There, the circulating water pumps are protected by a combination of bar racks and vertical traveling screens (Figure 2.9). Eight sets of vertical bar racks, consisting of 3/8-in. by 4-in. steel bars spaced five inches on center, prevent large debris from contacting the traveling screens. Design velocity through the bar racks is 0.46 m/s. Small debris, fish, and invertebrates are prevented from entering the cooling water system by conventional 3/8-in. mesh vertical traveling screens. Units 1 and 2 share four traveling screens, while Unit 3 has its own set of four traveling screens. The screens operate automatically when obstructed by debris or are rotated once each eight-hour work shift for debris removal. Debris, fish, and invertebrates are removed by high-pressure sprays and conveyed to trash baskets for disposal. Design through-screen velocity is 0.53 m/s.

Eight Peerless pumps are located at the east end of the screen and pump chamber. Units 1 and 2 each use two 590 revolutions per minute (rpm) pumps, rated at 39,000 gallons per minute (gpm), at a head of 7.92 m. Unit 3 uses four 510 rpm pumps, rated at 47,000 gpm, at a head of 11.58 m. Maximum combined flow for all units is approximately 495 mgd.

Seawater is pumped from the screen and pump chamber to the main steam condensers. The design temperature differential (ΔT) across the condensers for Units 1 and 2 is 18°F. The ΔT for Unit 3 is 14°F. After passing through their respective condensers, the flows are combined in

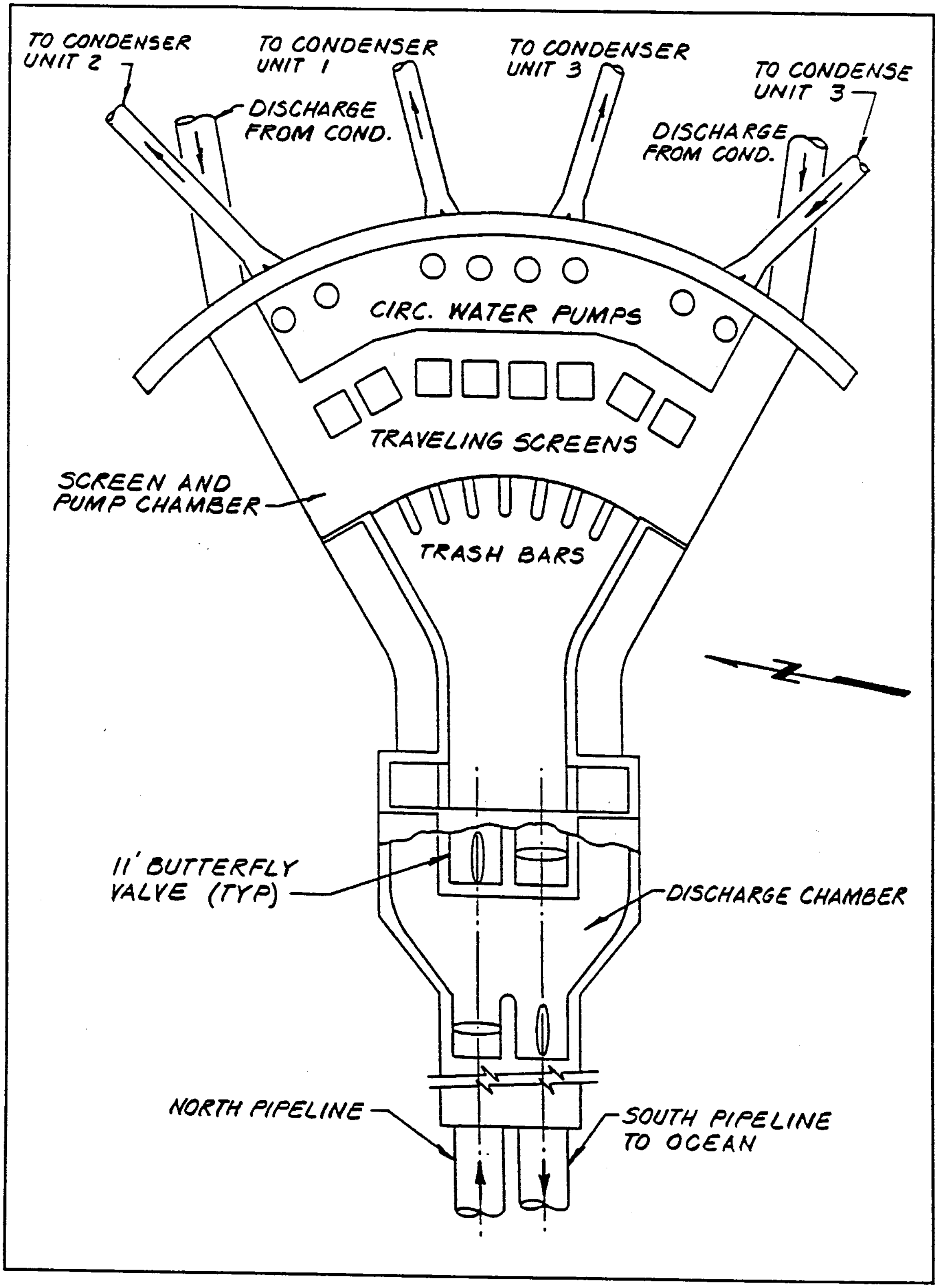

Figure 2.8. Scattergood Generating Station circulating water system (IRC 1981a).

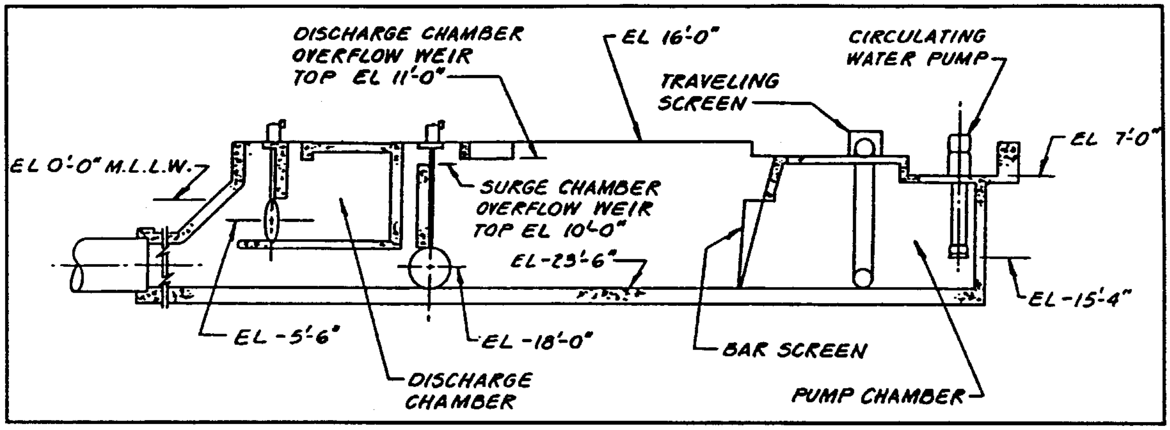

Figure 2.9. Profile of Scattergood Generating Station circulating water system and screen and pump chambers (IRC 1981a).

a single 3.66-m diameter underground discharge conduit parallel to the intake conduit, and conveyed approximately 366 m offshore. The warmed cooling water is discharged to Santa Monica Bay, approximately 122 m shoreward of the intake at a depth of about 4.6 m, through a vertical riser with an ID of 5.33 m, located in approximately 8.2 m of water (Figure 2.6).

Additions to the Cooling Water Stream

Products of other plant systems join the cooling water stream prior to discharge. Since these additions can potentially affect plankton or eggs which survive passage through the plant, concentrations discharged are closely monitored.

Condenser biofouling is controlled by treating the cooling water with chlorine before it passes through the condenser tubes. Chlorine concentrations in the discharged water are controlled at a level to be in compliance with existing National Pollutant Discharge Elimination System (NPDES) permit limitations. Other in-plant waste streams, such as boiler and cooling tower blowdown, water softener wastes, and rainfall runoff, are combined, after treatment, with the cooling water and discharged to the ocean. Chemical metal cleaning wastes, consisting of boiler acid rinses, are periodically generated, collected, and treated with alkaline chemicals in portable Baker tanks (CRWQCB 1995a). The treated effluent is transferred to settling basins where it mixes with low volume waste streams, which may include floor drains (after passing through an oil/water separator), nonchemical metal cleaning wastes (boiler and air preheater wash waters), reverse osmosis waste brine, boiler and evaporator blowdown, condensate polisher regeneration wastes, laboratory drains, and other low volume wastewaters generated in the plant. Residues in the basins and in Baker tanks are periodically transported to legal disposal sites. Cooling tower blowdown is sent directly to the outfall. Rainfall run-off is collected in a separate sump and is pumped to the outfall (Figure 2.10).

Heat Treatments

At Scattergood Generating Station, fish and invertebrate impingement data are collected during heat treatments. The fouling community and fish population present in the forebay and conduit system, which has accumulated since the last heat treatment, is effectively eliminated and examined by biologists.

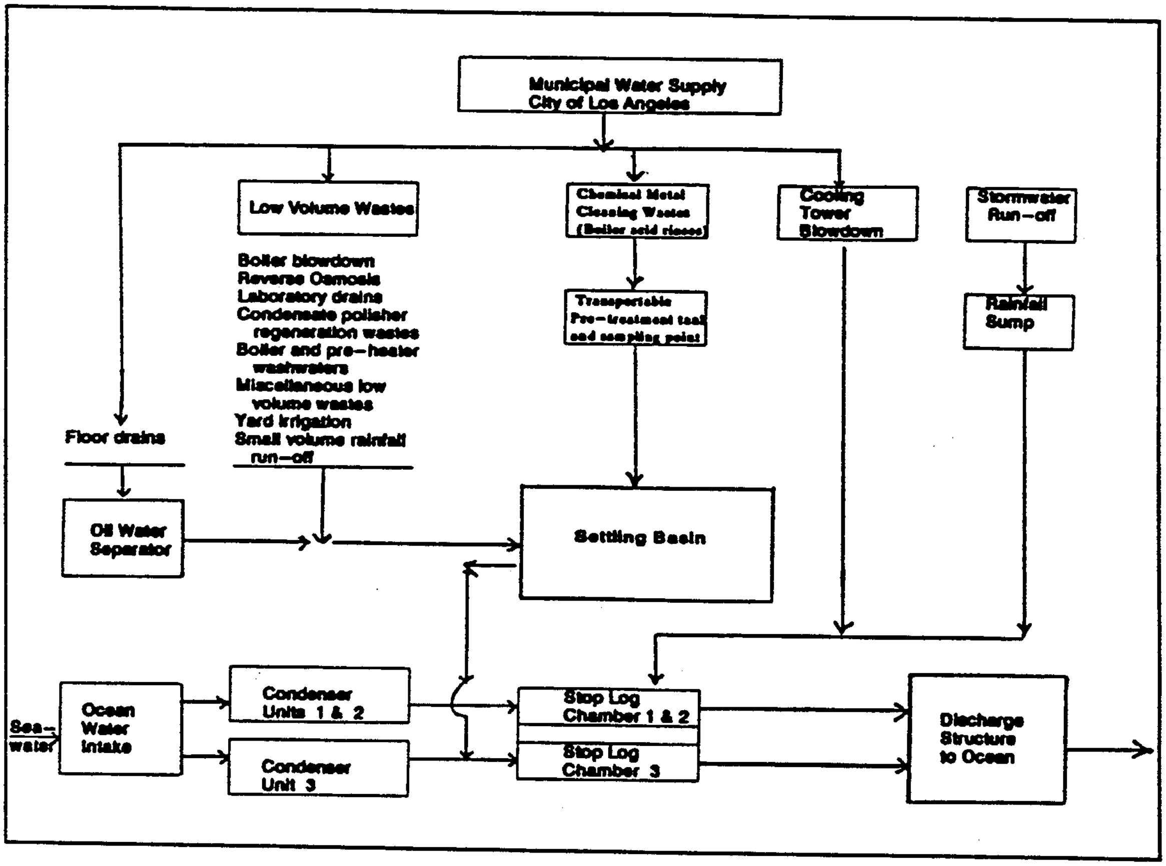

Figure 2.10. Schematic of wastewater flow at Scattergood Generating Station (CRWQCB 1995a).

The cooling water system is heat-treated approximately once every eight weeks to control the growth of marine fouling organisms. Valving at the screen and pump chamber allows recirculation of a portion of the cooling water in order to raise the condenser cooling water inlet temperature to approximately 115°F. This temperature, when maintained for 1.75 hrs, is sufficient to eliminate mussels, barnacles, and other fouling organisms which grow in and occlude the intake conduits. During this period, valving at the screen and pump chamber allows for reversal of cooling water flow, so that both the intake and discharge conduits can be effectively heat-treated.

During this procedure, the majority of the fish, invertebrates, and fouling organisms in the forebay and conduit system succumb to the increase in water temperature. Water flow into the plant carries these organisms to the travelling screens, which convey them from the forebay up to high-pressure sprays, which wash the organisms and small debris on the screens into a sluiceway. The sluiceway directs items to trash baskets situated at both ends of the travelling screens. A crane is needed to lift these baskets out of their wells and empty them for identification and categorization.

Depending on the amount of fish and debris in the sample, fish and invertebrates are quantified by two methods: complete and aliquot. If the contents are too large for biologists to sort and count all fish and invertebrates, a subsample, or aliquot, is made. All fish and invertebrates in the aliquot are sorted by species, counted, weighed, and up to 200 fish of each species are measured. Total species abundance and biomass are extrapolated from the subsample. The entire sample is examined for unusual or large species, which occur frequently, but in low numbers.

Fish and invertebrates are identified, and voucher specimens are occasionally brought back to laboratories for verification. Starting in 1992, standard length of up to 200 fish of each species was measured and recorded to the nearest 1 mm. Disc width (DW) and total length (TL) are measured on Pacific electric rays, round stingrays, and bat rays. Total length is measured on sharks and thornbacks. For California spiny lobster, carapace length and total length are measured, and sex is determined by examination of pleopods. If California spiny lobster appear healthy during examination, they are returned to the ocean immediately.

Total weight (in kg) is derived for each species of fish and invertebrate by using electronic or spring scales. Sex is determined by inspection of the gonads or external morphology for up to 50 individuals of certain species of fish.

Upon completion of sampling, written data are returned to the laboratory and entered in a spreadsheet program (Lotus 1-2-3).

Study Period Operating Characteristics

Operating characteristics for Scattergood Generating Station can best be described by analysis of the station generating capacity factors, and the cooling water flow requirements. The capacity factor is a measure of the actual plant generation to the plant generation capability. However, yearly or monthly capacity factors are a very general measure of operating characteristics. Daily and hourly generation fluctuations are not discernable from these values. Different cooling water temperature differentials associated with these fluctuations affect entrained organisms differently as well.

Cooling water flow rate is a more representative indicator of the station's operations and its effect on entrained organisms. A direct correlation exists between the amount of cooling water circulated and the number of organisms entrained. Since other waste streams contribute relatively little (0.1%) to the discharge volume at Scattergood Generating Station, circulating water flow is used to characterize total cycled cooling water volume.

Operating characteristics for the period October 1978 through September 1979 were described in detail in 1981 in a report on the Station's Cooling Water Intake Study 316(b) Demonstration Program, 1978-1979 (IRC 1981a). Total flow for the 1978-1979 study period was 140,800 million gallons, 78% of maximum design flow. That value was 20% higher than the average of 65% for the six years enveloping the study year, suggesting that any impacts associated with the Scattergood cooling water intake system on entrained organisms during the study year was at least representative of a normal year of operation.

Average annual flow from 1982 through 1995 was 106,594 million gallons (59% of maximum design yearly flow, and 76% of the 1978-1979 flow in the 1981 316(b) study) (LADWP 1996a, unpubl. data). Highest annual flow was in 1994 (136,399 million gallons), and lowest flow occurred in 1988 (60,944 million gallons). Figure 2.11 compares Scattergood Generating Station annual flow (million gallons) and average capacity from 1982-1995, while Figure 2.12 compares circulating water flow during the original 316(b) survey with circulating water flow between 1982 and 1995. Flow data are presented in Appendix A.

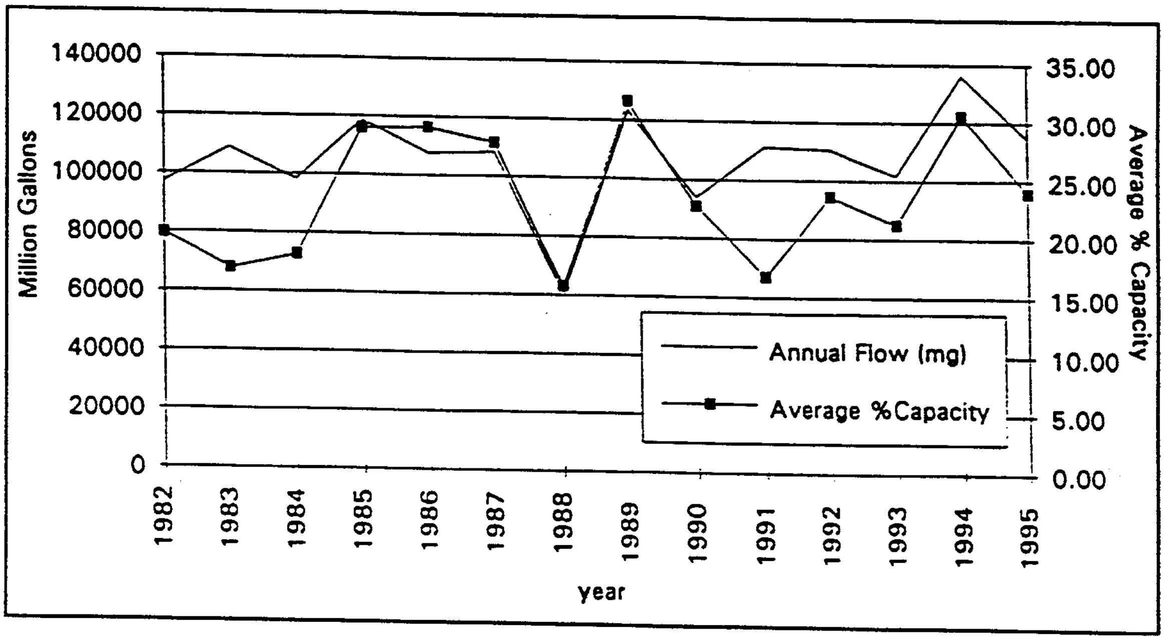

Figure 2.11. Comparison of Scattergood Generating Station annual circulating water flow (million gallons) and average generating capacity from 1982 through 1995.

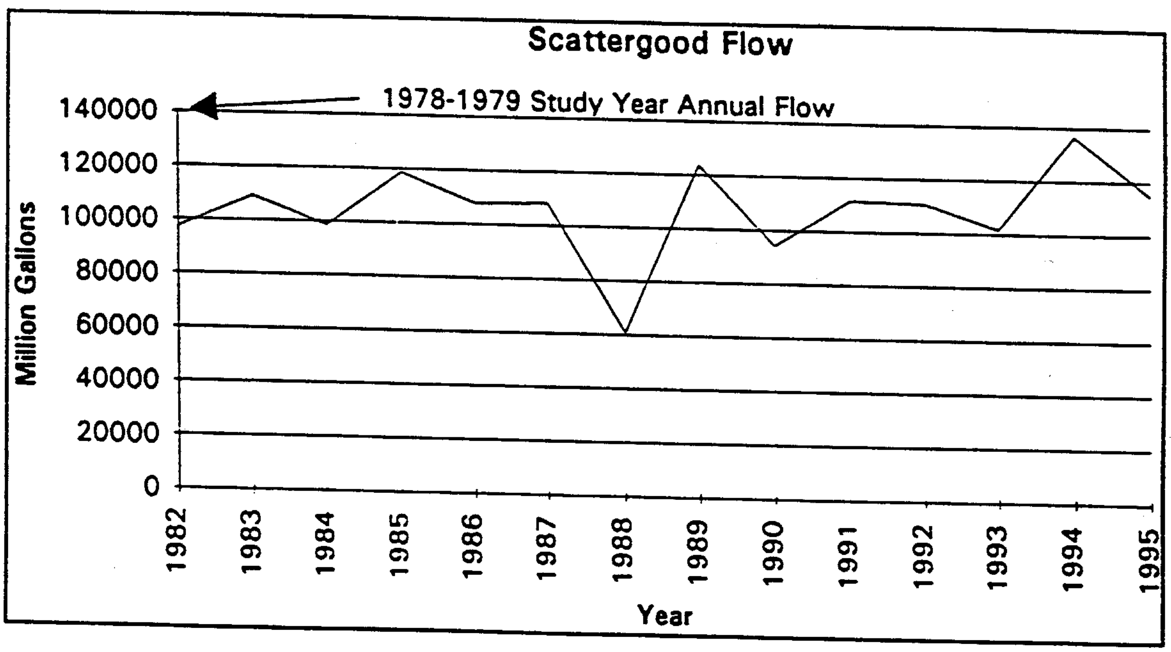

Figure 2.12. Comparison of Scattergood Generating Station annual circulating water flow (million gallons) from 1982 through 1995 with 1978-1979 study year circulating water flow.

From October 1978 through September 1979, the monthly capacity factor for Scattergood averaged 58%, compared with an average of 55% during the 10 years prior (Table 2.1). Monthly capacity factors varied from a low of 36% for May 1979 to a high of 83% for September 1979.

Monthly capacity factors between 1981 and 1995 have ranged from zero (April 1982) to 59.32% (November 1985). Average monthly capacity between October 1, 1981 and September 30, 1995 was 23.39% (R. Castro pers. comm. 1996).

The velocity cap located at the intake structure serves to redirect vertical intake flow into the conduit to a horizontal flow, which many fish can sense and escape more easily. The 1981 study included measurements of approach velocities to the velocity cap and to each of the traveling screens. Both approach and cross screen velocity components were found to experience flow direction reversals in the water column. The degree of reversal or turbulence is related to the position of the screen within the screen and pump chamber.

Table 2.1. Scattergood Generating Station monthly operating characteristics from 1978-1979 study year (modified from IRC 1981a).

Month	% Maximum Generating Capacity	Total Circulating Water Flow*
Oct-78	68	15,069
Nov-78	71	12,981
Dec-78	43	10,813
Jan-79	46	8,638
Feb-79	38	7,979
Mar-79	64	14,494
Apr-79	62	12,061
May-79	36	9,877
Jun-79	54	10,835
Jul-79	61	10,946
Aug-79	71	13,860
Sep-79	83	13,259

*Million gallons.

During the 1978-1979 survey, it was found that for normal Scattergood pumping conditions (365 mgd) at a distance of 20 m from the center of the intake velocity cap, intake-induced horizontal water velocity was estimated to be less than 0.015 m/s, too small to be measured by current meter. The capture cross-section of the three-dimensional "entrainment window" is elliptical. At the Scattergood intake, the window is about 42 m wide under conditions of 0.05 m/s ambient longshore current with maximum cooling water usage by the generating station. When the station operates at its more typical flow of 365 mgd, this width decreases to about 35 m (Figure 2.13). Due to the elevation of the intake opening above the bottom, the flow stream entering the intake does not intersect the bottom for ambient currents exceeding 0.07 m/s, and the greatest proportion of water entrained at Scattergood was found to originate outside the near field at mid-depth. However, during slack water, the vertical entrainment ellipse will graze both the water surface and the bottom. Thus, waters over the full depth of the intake site should be considered as potentially available for vertical entrainment.

MARINE BIOLOGICAL SETTING

Santa Monica Bay is adjacent to a highly urbanized area, and is utilized for a variety of industrial and recreational purposes. Since it receives controlled and uncontrolled discharges, the water quality of the bay has been under constant scrutiny for decades. In fact, Santa Monica Bay is one of the most intensely studied bodies of water on the west coast, with oceanographic and biological monitoring ongoing on a daily basis.

Within this body of water there resides a biological community which represents, or is the product of, the physical and chemical environment. The portion of this community subject to potential entrainment and impingement are the plankton and coastal fishes. The following is an analysis of resident plankton and fish populations in Santa Monica Bay, the source waters of the Scattergood Generating Station. This section will discuss critical taxa of the present study. Critical

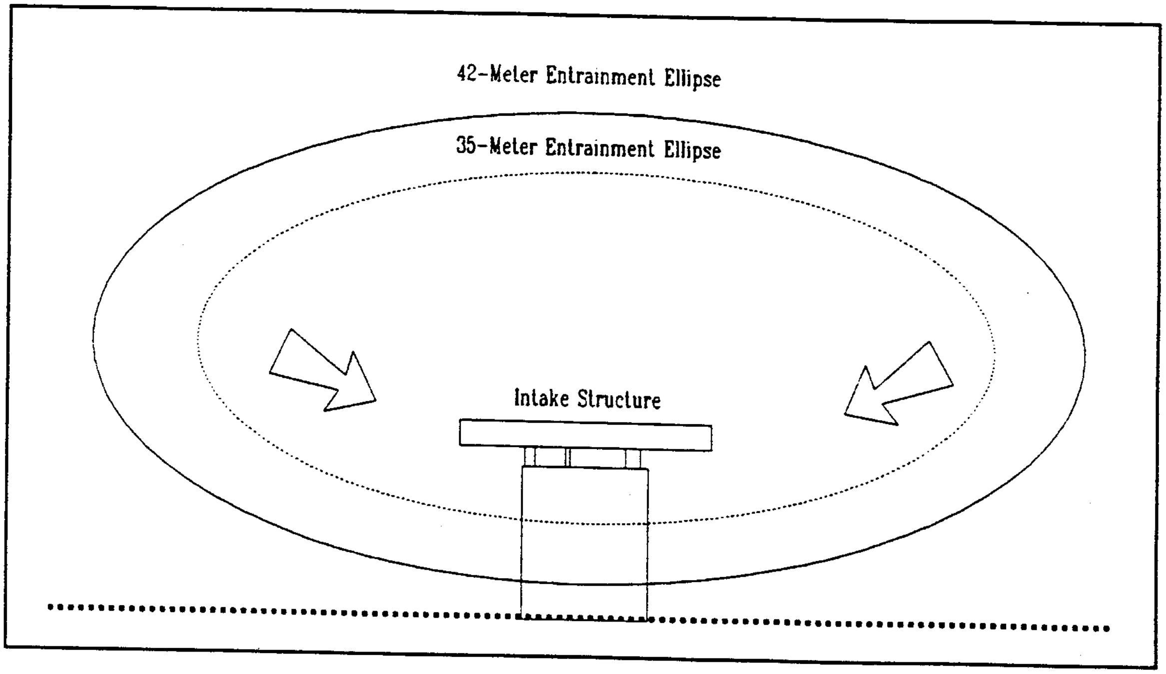

Figure 2.13. Scattergood Generating Station intake entrainment ellipse at maximum intake flow (42-meters) and typical flow (35-meters).

taxa of zooplankton, fish eggs, and ichthyoplankton are those chosen for the original 316(b) survey. Data from the 1978 and 1979 316(b) sampling effort represent the most comprehensive data available for these taxa in the study area. Critical taxa of fish are the fifteen species most abundant at heat treatments at Scattergood Generating Station between 1989 and 1995, as well as California halibut and white seabass.

Zooplankton

Zooplankton are divided into the holoplankton, which spend their entire life cycle as planktonic forms, and meroplankton, which represent planktonic larval stages of larger invertebrates. Zooplankton are the primary grazers of phytoplankton and other organic material; zooplankton may be filter feeders as well as predators on other zooplankton. In turn, they are consumed by larger, secondary consumers.

Over the continental shelf, zooplankton are found throughout the water column, although certain species are characteristic at various depths. Many planktonic crustaceans undertake a daily vertical migration, swimming to the surface at night and to deeper waters during the day.

Most holoplankton species reproduce several times in a single year, the life span of an individual being measured in weeks or months. Eggs are usually dispersed throughout the water and develop through a variety of larval stages to mature adults. Some zooplankton are the larval stages of macroinvertebrates, which reproduce less frequently.

Zooplankton abundances typically increase immediately following phytoplankton blooms, especially in spring, and the subsequent grazing by zooplankton contributes to a decline in phytoplankton. However, a decline in phytoplankton is primarily caused by depletion of nutrients. The volume of zooplankton in the surface waters of the Southern California Bight generally ranges from 900 to 3000 ml/1000 m^3 (Mullin 1986). In 1980, zooplankton (mostly copepod) volumes in Santa Monica Bay ranged from 100 to 1,300 ml/1,000 m^3 (Kleppel et al. 1982).

Critical species include the copepod *Acartia*, zoeae of *Cancer* and *Emerita analoga*, and the mysids *Acanthomysis macropsis*, *Neomysis kadiakensis*, and *Metamysidopsis elongata*.

The copepod *Acartia* is by far the most abundant species of zooplankton found in the vicinity of the Scattergood Generating Station at all depths. *Acartia* is a cosmopolitan species, inhabiting bays, estuaries, and nearshore waters throughout most of the world. It was originally chosen as a critical taxon because of its numerical dominance and year-round reproductivity.

The zoeae of crabs of the genus *Cancer* are common in the plankton population in the study area, as well as zoeae of the sand crab *Emerita analoga*. These organisms were chosen for they are representative of the indigenous benthic community in Santa Monica Bay.

Acanthomysis macropsis, *Neomysis kadiakensis*, and *Metamysidopsis elongata* were selected for they are indicators of the mysid population, which is an important food source in Santa Monica Bay. *Acanthomysis macropsis* and *Metamysidopsis elongata* are considered inshore species associated with neritic waters, bays and mud-flats. *Neomysis kadiakensis* is considered mainly an open water species and not a major inhabitant of enclosed bays. *Neomysis kadiakensis* is the only mysid studied considered an "open-water" species, not choosing bays and estuaries as its primary habitat.

Non-critical species include other copepods, chaetognaths, larvaceans, cladocerans, *Neotrypaea* species zoeae (formerly *Callianassa* spp.), other decapod zoeae, ostracods, and other mysids. *Cancer* spp. zoeae are often associated with rock structures along the open coast or outer bays.

Fish Eggs

Fish eggs are often grouped with plankton since their distribution is determined by passive transport. Three critical fish egg taxa were selected during the 1981 316(b) demonstration: northern anchovy, flatfish of the genus *Pleuronichthys*, and Sciaenid species complex. Non-critical taxa included eggs from slough anchovy and deepbody anchovy (referred to as *Anchoa* spp.) and unidentified teleosts. These species will be discussed in the present study.

Ichthyoplankton

Ichthyoplankton refers to the planktonic egg and larval stages of bony fish. Most fishes release eggs and sperm in the water column. Fertilization is external, and both eggs and larvae are subject to oceanic diffusion and advection. Even among species that bear live young or attach their eggs to a substrate, the newly hatched larvae are usually pelagic.

Northern anchovy, queenfish, and white croaker are abundant nearshore spawners, as well as California halibut, sea basses (*Paralabrax* spp.), and Pacific sardine (Lavenberg et al. 1986).

The sciaenids white croaker, queenfish, white seabass, and yellowfin croaker are common throughout the Southern California Bight in open coast and bay environments. Spawning occurs over a large area, and extremely high fecundity and high natural mortality rates for larvae of these taxa are common.

Nearby Marina del Rey serves as a shallow, warm water, high nutrient environment for fish eggs, larvae, and young adults. This environment has been monitored twice per year since 1984 (surveys in May and October), and abundant species of ichthyoplankton have been identified (Soule et al. 1996). Gobiidae Type A/C larvae, which include larvae of cheekspot goby, shadow goby, and arrow goby, have been found in every May and October survey since 1984. All three of these fish prefer shallow bays and channels of tidal mudflats (MacDonald 1972), and may spend their entire lives in the Marina. *Hypsoblennius* spp. larvae, which include larvae of bay blenny, rockpool blenny, and mussel blenny, have also been found in every survey. These species are commonly found in rocky subtidal, rocky intertidal, and bay environments (Brewer and Lavenberg 1979). Other species of larvae found in October 1994 and May 1995 include northern anchovy (eggs and larvae), California clingfish, reef finspot, and unknown eggs. Larvae of species present in October 1994 are spotted kelpfish, Gobiidae non A/C larvae, giant kelpfish, and Pleuronectidae larvae, while those present in May 1995 include arrow goby and blind goby (Soule et al. 1996).

Seasonality is generally a factor in the abundance of certain species of ichthyoplankton, with larger concentrations of ichthyoplankton being present during and immediately after spawning seasons. Northern anchovy spawn year-round, with peaks from December to May (Love, 1991). White croaker also spawn throughout the year, but most spawn from October into April, while Queenfish generally spawn between April and August (Goldberg 1976).

The following critical ichthyoplankton species were selected to represent different aspects of the plankton trophic community. The Atherinid species complex represents planktivorous fish inhabiting waters near the surface. The Engraulid species complex (anchovies) is part of an important commercially valuable fish resource, while *Sebastes* spp. (rockfish) and *Pleuronichthys* spp. (turbot) are also popular sport fish. Larval sciaenids (*Genyonemus lineatus* and *Seriphus politus*) represent the most dominant adult fish in source water.

Non-critical taxa included the Gobiid species complex, *Hypsoblennius* spp., diamond turbot, and unidentified teleosts.

Nearshore Fish Community

Santa Monica Bay provides a variety of habitat to support a diverse fish community. Most nearshore areas within the bay are characterized by a fine sand sea floor. However, at the northerly and southerly extremes of Santa Monica Bay, rocky areas of the seafloor are common and support stands of giant kelp. Throughout the nearshore areas of Santa Monica Bay, man-made structures, such as artificial reefs, harbor environs, and offshore pipelines and discharge structures, combine to produce a variety of habitats for marine life.

Several species of fish utilize kelp beds for schooling, foraging, and shelter. Kelp bass, black surfperch, rubberlip surfperch, opaleye, kelp rockfish, and olive rockfish are common in kelp holdfast zones (MBC 1993b). Yellowtail, white seabass, rubberlip surfperch, halfmoon, and halfblind goby are known to occupy the stipe region of kelp beds. Fishes common in the canopy of kelp beds include topsmelt, kelp pipefish, kelp perch, giant kelpfish, kelp clingfish, and kelp gunnel.

Flatfish, rockfish, sculpin, combfish, and eelpouts comprise the vast majority of soft-bottom fish fauna (MBC 1993b). The inner shelf assemblage is dominated by speckled sanddab, the middle shelf by stripetail rockfish, and the outer shelf by slender sole (Allen 1982).

California halibut, California scorpionfish, barred sand bass, California corbina, and white croaker are targeted by sportfishermen. Fish that spend the majority of their time on the bottom, such as California halibut, are less likely to be affected by the currents associated with the elevated intake riser at Scattergood Generating Station. Other fish which spend considerable time on the sea floor, but disperse to feed in the water column, such as barred sand bass, will be susceptible to impingement at times. Fishes associated with underwater structures (kelp bass, blacksmith, and sargo) probably use the intake structure as a foraging area, as well as for primary habitat.

Common shallow water fish which prefer hard-bottom habitat are seabass, surfperch, rockfish, kelpfish, sculpin, greenlings, damselfish, and wrasses. Important species include kelp bass, brown rockfish, pile perch, black perch, white seaperch, rubberlip surfperch, señorita, and opaleye (MBC 1993b). Rockfish and kelp bass are the most important sport fish in the bay, rockfish occurring in deep water, kelp bass primarily in shallow water. The surfperch, which also use the intake structure as a foraging area, are unlike any of the above mentioned fishes in that they are viviparous and do not disperse eggs or sperm throughout the water column. Instead, fertilization is internal, and perch generally bear 10 to 30 individuals at one time. Walleye surfperch is the surfperch examined in this study; females of this species produce up to 19 young.

Fishes found in the rocky intertidal include woolly sculpin, opaleye, rockpool blenny, spotted kelpfish, and California clingfish.

The only fish found in the sandy intertidal habitat are California grunion, which use sandy beaches as spawning grounds from late February to early September (MBC 1988).

The wetlands at Ballona Creek support several transient species of fish, but only nine resident species (MBC 1988). Dominant species are arrow goby, mosquitofish (a freshwater species), and topsmelt. Topsmelt, along with jacksmelt and salema, usually occur in schools in a variety of habitats, including bays and estuaries, kelp beds, and sandy beaches. Jacksmelt have been observed at depths of 95 ft (Love 1991).

Dominant pelagic fishes include chub mackerel, jack mackerel, northern anchovy, and Pacific sardine (MBC 1988). Pelagic sport fishes, such as yellowtail and Pacific barracuda, are migratory and will move into the bay in summer. In the 1980s, chub mackerel and Pacific bonito accounted for about 27% and 13%, respectively, of the sport fish catch in Santa Monica Bay (MBC 1988). Open-water schooling fishes, such as jack mackerel, Pacific sardine, and chub mackerel, are distributed throughout the Southern California Bight as well, and the area around the intake is probably not their primary habitat; however, they may use this area to feed or school.

Critical Fish Species

The original 316(b) demonstration (IRC 1981a) selected five species of adult fishes for examination. These species were northern anchovy, white croaker, queenfish, California corbina, and walleye surfperch. For the present study, the list of critical species (Table 2.2) has been expanded to include those most abundant, most frequently occurring, and those supporting fisheries. With the exception of California corbina, the adult species selected in 1981 are included

Table 2.2. Seventeen critical fish species for Scattergood Generating Station 1996 316(b).

Species	Common Name
1 *Trachurus symmetricus*	jack mackerel
2 *Seriphus politus*	queenfish
3 *Atherinops affinis*	topsmelt
4 *Atherinopsis californiensis*	jacksmelt
5 *Engraulis mordax*	northern anchovy
6 *Sardinops sagax*	Pacific sardine
7 *Genyonemus lineatus*	white croaker
8 *Xenistius californiensis*	salema
9 *Umbrina roncador*	yellowfin croaker
10 *Hyperprosopon argenteum*	walleye surfperch
11 *Anisotremus davidsonii*	sargo
12 *Scomber japonicus*	chub mackerel
13 *Paralabrax nebulifer*	barred sand bass
14 *Chromis punctipinnis*	blacksmith
15 *Paralabrax clathratus*	kelp bass
16 *Atractoscion nobilis*	white seabass
17 *Paralichthys californicus*	California halibut

in the present evaluation. The California corbina was not included because of its low impingement numbers and frequency of occurrence.

The selected species characterize fish losses from normal operations, and represent a cross-section of life history and trophic types for the nearshore waters of southern California.

Fish Populations Composition

Data for fish species identified during trawl surveys in Santa Monica Bay are in Appendix B (OC 1987, 1989; CLA-EMD 1996, unpubl. data). Fish taken on sportfishing vessels in Santa Monica Bay during the years 1959, 1967, 1975, 1983, and 1991-1994 are listed in Appendices C and D (CDFG 1996, unpubl. data; Los Angeles Times 1959-1994). Fish quantified during Scattergood Generating Station heat treatments are shown in Appendix E (LADWP 1996b, unpubl. data). Ulrey and Greeley (1928) listed fishes of southern California and their distribution; of importance to this survey are fishes observed in Santa Monica Bay. Carlisle (1969) sampled 39 stations in Santa Monica Bay between 1958 and 1963; a total of 705 bottom tows were made in 60 to 600 ft of water. Duration of tows was ten minutes. Fay et al. (1978) made 596 tows in Santa Monica Bay between 1969 and 1973; depths sampled ranged from 17 to 653 ft. Trawls were 15 minutes and the net was towed at a speed of one knot.

For the original 316(b) demonstration, fish were sampled during three heat treatments at Scattergood Generating Station in November 1978, January 1979, and August 1979 (IRC 1981a). Fish were also sampled during 35 heat treatments at Scattergood Generating Station between 1989 and 1995 (MBC unpubl. data, Appendix E). In July and August of 1994, 13 stations in Santa Monica Bay were trawled for the Southern California Bight Pilot Project. These stations varied in depth from 14 to 83 m (SCCWRP 1994, unpubl. data). Trawl duration was 10 minutes and trawl speed was 1.5 to 2 kn.

Figure 2.14 illustrates possible trophic relationships of critical fish species found in the nearshore areas of the Scattergood Generating Station. These species impinged between 1989 and 1995 will be discussed in order of decreasing abundance. Abundance of fish impinged should not be considered proportionate to relative abundance of existing populations, since some species are more susceptible to impingement.

Standing stock numbers were derived from 96 trawls done in winter and summer 1986 and 1988 for Scattergood Generating Station NPDES monitoring programs. Two replicate trawls were made at 12 stations (between 20 and 60 ft depths). Trawl duration was five minutes at a

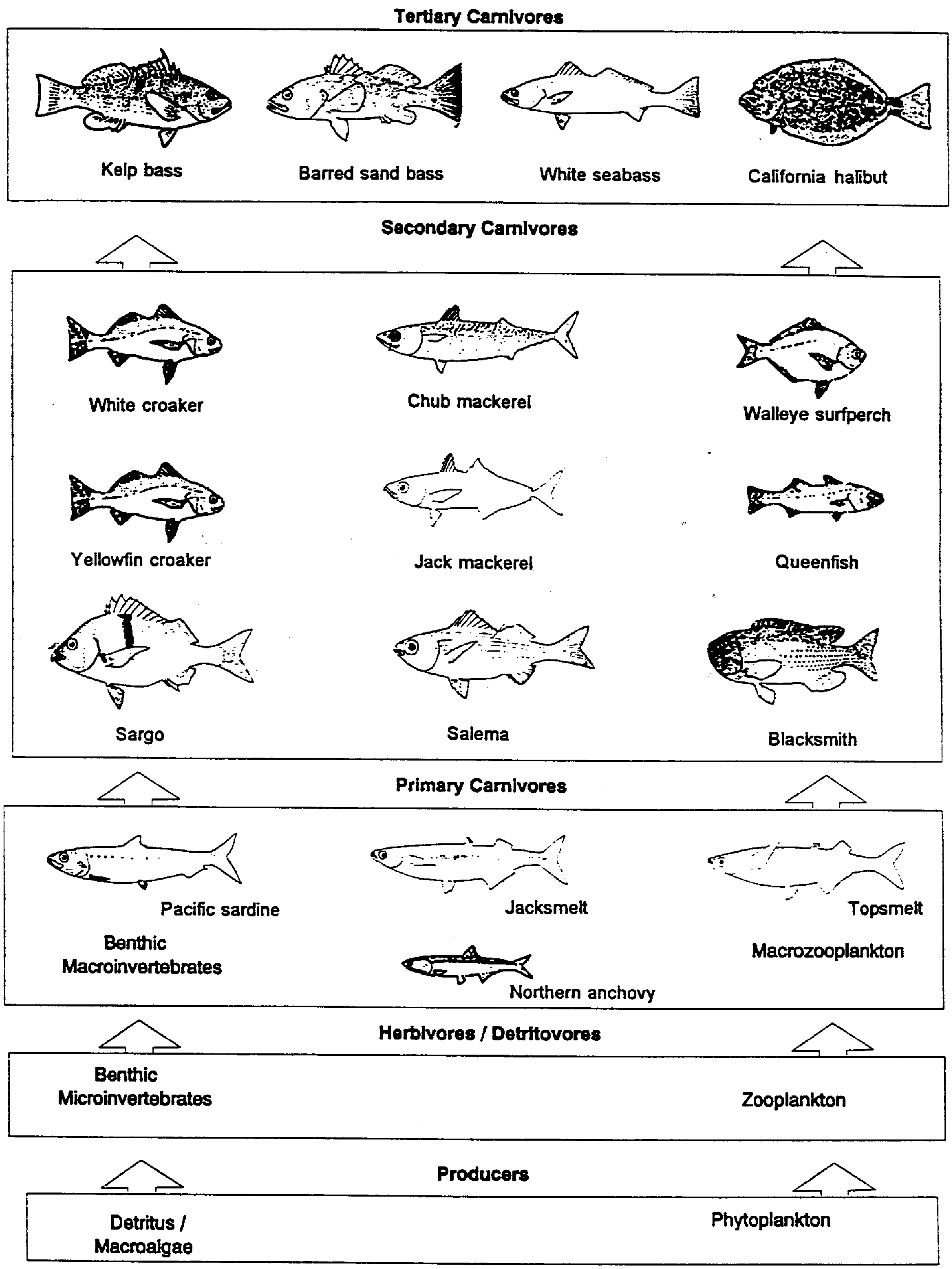

Figure 2.14. Possible trophic relationships of critical fish species (modified from Dailey et al., 1993).

speed of 2 to 2.5 knots The average CPUE (catch per unit effort) for certain species of fish for the four surveys was multiplied by the ratio of source water volume to trawl volume to obtain a standing stock number. This number was weighted toward 12%, 30%, and 50% catch efficiencies of otter trawls. Stephens et al. (1974) estimated otter trawl catch efficiencies to be somewhere between 12 and 30%. For this study, 50% has been added solely as a comparative tool. Data from 53 trawls made in Santa Monica Bay during the years 1990-1992 and 1994-1996 as part of Hyperion Treatment Plant's marine monitoring program are also used. Trawls were made quarterly at four stations. Station locations ranged from offshore Santa Monica to offshore El Segundo Generating Station (just south of Scattergood Generating Station). Depths ranged from 49 to 200 ft.; trawl duration was ten minutes at a speed of 1.8 to 2.1 knots. Monitoring for Hyperion Treatment Plant occurs in deeper water than monitoring for Scattergood Generating Station, so species composition is different than seen in trawls for Scattergood Generating Station. However, California halibut are taken in sufficient numbers in the deeper trawls to provide a standing stock estimate.

Trachurus symmetricus. Jack mackerel is a schooling species commonly found near the surface (Love 1991). Small fish (less than 16 in. or 406 mm) are found over shallow rocky reefs and along rocky shorelines of the coast of southern California, usually at depths shallower than 200 ft (Leet et al. 1992). Larger fish are found offshore and farther north, and do not form large, dense schools like younger fish. Spawning occurs inshore and offshore (Love 1991). Jack mackerel have not been abundant in nearshore trawls, so standing stock estimates for this species have not been derived.

Seriphus politus. Queenfish is a schooling species commonly found over sandy bottoms (Love 1991), and is frequently abundant in coastal trawl surveys in the Southern California Bight (MBC 1995a). They usually remain inshore during the day and move offshore at night (Eschmeyer et al. 1983). Queenfish was the most abundant fish trawled on the 6.1 m (20 ft) isobath at three stations in Santa Monica Bay in a trawl survey conducted between 1982 and 1984; stations were located offshore Torrance, Redondo Beach, and Venice (Love et al. 1986). Standing stock estimates range from 9.90×10^7 to 4.12×10^8 individuals.

***Atherinops affinis* and *Atherinopsis californiensis*.** Topsmelt are surface-dwelling schoolers, which mainly feed on plankton (Love 1991). They are active during the day and become quiescent at night (Love 1991). Jacksmelt are also a schooling fish, preferring waters in the 5- to 50-ft depth range (CDFG 1987). Jacksmelt are the largest of the silversides on the West Coast; they eat plankton and small fish (Love 1991) and form larger schools than topsmelt (Leet et al. 1992). These fish may feed on plankton entrained by the intake flow of the Scattergood Generating Station. These fish are not common in bottom trawls, so standing stock estimates were not made.

Engraulis mordax. Northern anchovy move offshore in the winter and return inshore in the spring (MBC 1987). They are one of the most abundant fishes off California, and important prey item for many fish, seabirds, and marine mammals. Anchovy themselves are filter-feeders, preying mostly on plankton, and occasionally on fish eggs, including anchovy eggs (Leet et al. 1992). Northern anchovy are a common sport fish bait. Estimates of standing stock range from 2.08×10^8 to 8.67×10^8 individuals in the source waters.

Sardinops sagax. Sardines are schooling filter feeders, and prey mostly on copepods and other plankton, including fish larvae and ichthyoplankton (Leet et al. 1992). Schools off the coast of California were once thought to contain 10 million or more individuals (Fitch and Lavenberg

1971). They are commonly found nearshore, but may be found hundreds of miles off the coast (Love 1991).

A large fishery for this species existed from the early 1900s through the 1940s. The Pacific sardine supported the largest fishery in the western hemisphere during the 1930 and 1940s (Leet et al. 1992). The fishery collapsed in the late 1940s and its demise continued through the 1960s. In 1974, a moratorium was placed on sardine fishing. Since the mid- to late-1980s, it appears the sardine populations are re-establishing themselves. Reasons for the decrease in the sardine population were most likely the combination of fishing pressure and natural environmental changes. Sardine are still a valued bait fish. Pacific sardine were present in trawls only during the summer 1986 survey, and estimates range from 3.53 X 10^6 to 1.47 X 10^7 individuals.

***Genyonemus lineatus*.** White croaker are a schooling species common in coastal trawl catches throughout the Southern California Bight, usually found near sandy or mud bottoms (MBC 1995). They are usually found at depths of 10 to 100 ft (Leet et al. 1992). These fish prey on small fishes (such as northern anchovy), crustaceans, clams, and polychaetes (Love et al. 1984). In turn, white croaker are preyed upon by larger fishes, such as California halibut, spiny dogfish, and barred sand bass (Love 1991). White croaker seem to move inshore during summer months and offshore in winter. Standing stock estimates vary from 8.21 X 10^7 to 3.42 X 10^8 individuals.

***Xenistius californiensis*.** Salema are a nearshore species frequently found around rocks or among kelp to depths of 35 ft (Goodson 1988). They are nocturnal feeders, mainly preying on plankton and small invertebrates. Salema school in loose aggregations of perhaps ten to several hundred individuals (Fitch and Lavenberg 1975). Juvenile salema are sometimes seen schooling with black croaker and sargo of similar sizes. Spawning occurs in spring and summer. No standing stock estimates were made for salema as they were not abundant in bottom trawls.

***Umbrina roncador*.** Yellowfin croaker are shallow water schoolers, are common inshore to depths of about 25 ft, and are most abundant from July to September (Love 1991). Yellowfin croaker feed on small fish, crabs, worms, clams, and small crustaceans (Goodson 1988). They school close to sandy beaches during the day, and disperse at nightfall to feed in nearby areas (Hobson et al. 1981). Standing stock estimates range from 5.23 X 10^5 to 2.18 X 10^6 individuals.

***Hyperprosopon argenteum*.** During the day, walleye surfperch form dense schools and aggregate along sandy beaches and sand-rock margins at depths of up to 100 ft (Love 1991). At night, they disperse to depths just above bottom and feed on zooplankton. All surfperch are viviparous; their young are highly developed and free swimming at birth (Leet et al. 1992). Population estimates range from 5.37 X 10^5 to 2.24 X 10^6 individuals in the source waters.

***Anisotremus davidsonii*.** Sargo are usually found near bottom at a depth of about 40 ft, but have been found in waters as deep as 130 ft (Love 1991). They are most abundant in the vicinity of kelp beds and other shallow environments providing relief, such as rocks and pier pilings (Fitch and Lavenberg 1971). They are usually present in loose schools or aggregations (Eschmeyer et al. 1983). Sargo were not present in sufficient numbers to warrant population analysis.

***Scomber japonicus*.** Chub mackerel form large schools and are commonly found near the surface, though they can be found in several hundred feet of water (Love 1991). These fish undertake vertical diel migrations, ascending to the surface at night (MBC 1987). There is also an inshore-offshore migration; these fish are more abundant inshore from July to November (Leet et al. 1992). Juvenile and adult chub mackerel feed in the water column, mainly on larval and juvenile fishes, as well as on squid and crustaceans, such as euphausiids (MBC 1987). Chub mackerel are fed on by porpoises, sea lions, yellowtail, white seabass, marlin, sharks, and other large predators (Fitch and Lavenberg 1971). They are also commonly caught by sportfishermen and used as bait. Chub mackerel were not abundant in trawls, so no population estimates were made.

Paralabrax nebulifer. Since the late 1970s, barred sand bass has consistently ranked among the top 10 species in the southern California marine sport fish catch (Leet et al. 1992). They are common at depths from 10 to 120 ft, but may venture out into deeper water (perhaps up to 600 ft) (Love 1991). Although they do not form massive schools, barred sand bass are rarely seen alone, and seem to prefer the company of at least a few other bass. As their name implies, they are common over sand bottoms, and also congregate at the sand-rock interface. The mainstay of their diet includes small fishes and invertebrates. Population estimates from trawl-caught barred sand bass range from 1.77 X 10^6 to 7.36 X 10^6 individuals.

Chromis punctipinnis. Blacksmith are abundant around shallow rocky areas (Fitch and Lavenberg 1971). During the day, they form dense schools in mid-water, usually over reefs, and feed on zooplankton (Love 1991). At night, they retreat to crevices or sand near crevices. These fish have been seen interacting with inwardly flowing water currents at other generating station intake structures, exhibiting positive rheotaxis, and maintaining position with the flow of water (Helvey and Dorn 1981). Blacksmith occurred in only one of the four trawl surveys, and standing stock estimates range from 1.30 X 10^6 to 5.42 X 10^6 individuals in the source waters.

Paralabrax clathratus. Kelp bass are mainly associated with kelp beds, rocks, and seaweeds. They are found in waters up to 150 ft deep, but are most concentrated at depths of 10 to 70 ft (Love 1991). They are mostly solitary fish, but form assemblies to spawn and to feed on smaller fish (Leet et al. 1992), which include anchovies and surfperch (CDFG 1987). This extremely popular sport fish also feeds on octopi, squid, crabs, shrimp, and algae (Love 1991). Population estimates vary from 7.07 X 10^5 to 2.94 X 10^6 individuals.

Atractoscion nobilis. Juvenile white seabass prefer shallow inshore habitats, often near rocks or kelp. Adults can be found there, but some may move offshore in winter to depths of 120-350 ft (Love 1991). Adult white seabass eat other fish, squid, and crabs. A strong commercial fishery for white seabass existed for many years; however, since 1959, the fishery has declined (Leet et al. 1992). Currently, efforts are being made to rejuvenate populations of this prize sport fish, which may live to be twenty years of age (Fitch and Lavenberg 1971). White seabass occurred only in the summer 1988 trawl survey, and population estimates derived from its abundance range from 5.66 X 10^4 to 2.36 X 10^5 individuals in the source waters.

Paralichthys californicus. Juvenile California halibut prefer sand and mud bottoms off coastal embayments and estuaries, while adults are common from the surf zone to depths of 600 ft, but are uncommon at depths greater than 200 ft (MBC 1987). Adults prefer sandy nearshore areas and are commonly found near rocks and sand dollar beds (MBC 1987); they are also known to inhabit areas near rocks and artificial reefs (Love 1991). They feed almost exclusively on anchovies, queenfish, and other small fishes (Fitch and Lavenberg 1971). California halibut tend to move inshore in late winter and early spring to feed and spawn (Love 1991). California halibut are a popular sport fish in southern California, and a commercial fishery exists for this species (Leet et al. 1992). Standing stock estimates from Scattergood Generating Station trawl surveys range from 1.21 X 10^7 to 5.06 X 10^7 individuals, while estimates from Hyperion Treatment Plant trawl surveys range from 7.20 X 10^6 to 3.00 X 10^7 individuals in the source waters.

1978-1979 PLANKTON STUDY

Between 1978 and 1979, much effort was put into characterizing the plankton population at near- and far-field stations off of the Scattergood Generating Station (Figure 2.15) (IRC 1981a). The near-field station was located within a 50-m radius of the intake riser. There were two far-field stations which served as control stations; one 3,800 m upcoast on the intake isobath, and another 2,400 m directly offshore of the intake. This information will be used to characterize zoo- and ichthyoplankton populations in the study area between 1981 and 1995.

Zooplankton

Seasonality

Most critical zooplankton taxa were more abundant during the spring and summer than in the fall and winter. Only *Cancer* spp. zoeae showed no consistent pattern, probably because as many as five species of *Cancer*, which have overlapping breeding periods, reside in the study area. The observed seasonal patterns of abundance are consistent with results of other studies conducted in southern California waters.

Spatial Patterns

Acartia species (adults and copepodites), *Acanthomysis macropsis*, and *Metamysidopsis elongata* all had greater densities at the shallow water stations than at the deeper station. *Cancer* zoeae and *Neomysis kadiakensis* had approximately equal densities at deep and shallow water stations. Zoeae of the sand crab, *Emerita analoga*, were more abundant at the deep water station. These results are generally in agreement with published data of the onshore-offshore distribution of these animals.

Diel Patterns

Organisms of all zooplankton were generally more abundant at night. This may be attributed to net avoidance during the day, diel changes in regions of greatest density, or movement into the water column from the bottom at night.

Vertical Patterns

All taxa of zooplankton studied were generally more abundant in the mid-depth and bottom strata during the day. At night, vertical stratification was less distinct. Most taxa moved upwards in the water column at night. The most distinct vertical distribution pattern was exhibited by the mysids, and the least distinct was exhibited by *Acartia* spp.

Fish Eggs

Seasonality

At both near- and far-field stations, fish eggs were more abundant from winter through spring, and least abundant in fall. Eggs of all critical taxa followed the same general pattern of seasonal density, which agrees with known spawning times of these fish in southern California.

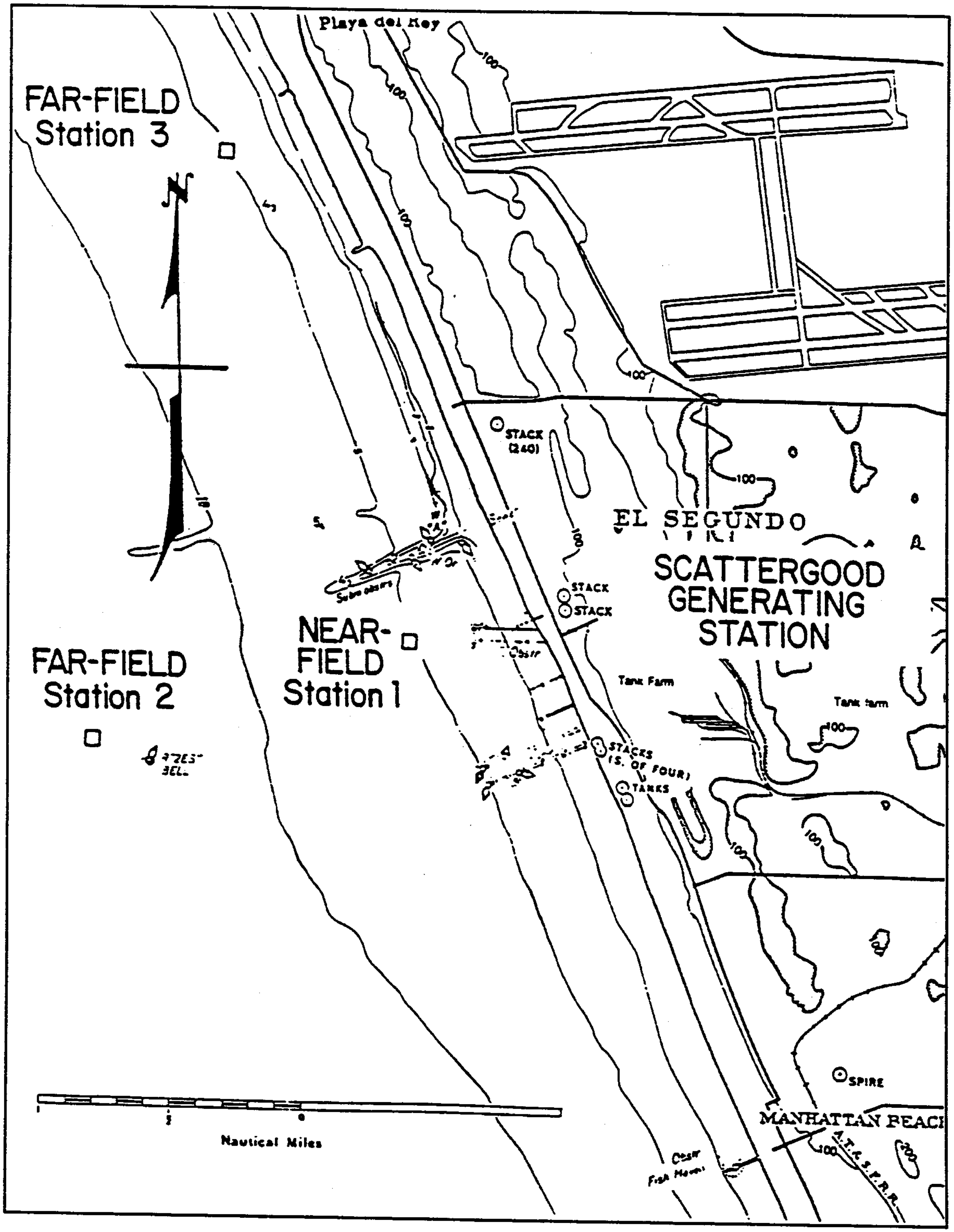

Figure 2.15. Location of near-field and far-field plankton stations from 1978-1979 (IRC 1981a).

Spatial Patterns

Pleuronichthys spp. eggs were equally abundant inshore and offshore. Sciaenid species complex eggs were more abundant at the shallower inshore stations, while northern anchovy eggs were more abundant at the offshore station. This pattern reflects spawning areas of these fish.

Diel Patterns

Sciaenid species complex eggs were more abundant at night at the two inshore stations, but not at the offshore station. This could be due to spawning inshore, followed by egg dispersal offshore during the day. No pattern of diel variation was observed for northern anchovy or *Pleuronichthys* spp.

Vertical Patterns

Sciaenid species complex eggs were more abundant with increasing depth. This could be attributed to specific gravities of the eggs. Northern anchovy and *Pleuronichthys* spp. eggs exhibited no distinct pattern of vertical distribution.

Ichthyoplankton

Seasonality

At near- and far-field stations, critical taxa of fish larvae exhibited periods of high density, primarily from winter through summer, and were least abundant in fall. Atherinid species complex larvae were most abundant in the spring and summer. Engraulid species complex larvae were most abundant in winter through spring. White croaker larvae were most abundant in winter and spring, while queenfish larvae were most abundant during spring and summer. Larvae of *Sebastes* spp. were most abundant in winter and spring, while *Pleuronichthys* spp. larvae occurred sporadically during the study.

Spatial Patterns

Atherinid species complex larvae were more abundant inshore, while engraulid larvae were found in greater numbers at the deep, offshore station. White croaker, queenfish, and other sciaenid larvae exhibited no distinct patter of distribution. Larval *Sebastes* spp. tended to be more numerous at the deep, offshore station, while *Pleuronichthys* spp. larvae tended to be equally abundant at all stations. The general distribution of fish larvae corresponds to the preferred habitat and spawning area of adults.

Diel Patterns

Sciaenid larvae were generally more abundant at night. Atherinid and engraulid species complex larvae exhibited no diel difference in density. Differences in density may be attributed to net avoidance by some fish during the day.

Vertical Patterns

Atherinid larvae were more abundant in surface waters than in mid-depth or bottom strata. Most common fish larvae were abundant in mid-depth regions. Generally, larger larvae tended to be found in the lower strata.

1981 HEAT TREATMENT AND IMPINGEMENT/VELOCITY CAP STUDY

One way of assessing existing nearshore fish populations offshore of the Scattergood Generating Station is to examine which species are impinged at the intake structure. Five critical fish species were chosen for the 1981 demonstration: northern anchovy, white croaker, walleye surfperch, California corbina, and queenfish. Fish mortality was evaluated with a two-phase approach. The first phase assessed impingement mortality during three heat treatments and previous LADWP studies. The second evaluated the effects of time of day, flow rate, and volume on impingement.

Heat Treatments

During three heat treatments, 20,104 fish weighing 6,939 lbs (3147.5 kg) were impinged. Queenfish was frequently impinged during heat treatments, representing 73% of total heat treat abundance.

Walleye surfperch was the second most frequently impinged species, representing 10% of total heat treat abundance. Northern anchovy, white croaker, and California corbina were infrequently caught during the three heat treatments.

Abundant non-critical taxa included kelp bass and shiner perch, which were abundant during the November 1978 heat treatment. White surfperch, shiner perch, and pile perch were dominant at the January 1979 heat treatment, and kelp bass and sargo were the most abundant non-critical taxa at the August 1979 heat treatment.

Impingement and Velocity Cap Study

A study evaluating the effectiveness of the velocity cap was conducted in April 1979. Fish impinged in the cooling water system were examined, and fish in the near-field area of the intake were sampled during the day and night using gill nets.

Queenfish, white croaker, and walleye surfperch comprised 92% of the total impingement catch. White surfperch and shiner perch were the most abundant non-critical fish captured.

Impingement of queenfish and walleye surfperch was greater at night than during the day. Smaller individuals of queenfish were generally more abundant, while larger individuals of white croaker and walleye surfperch were more common than smaller fish.

At night time, total numbers of impinged fish were significantly greater during periods of low and medium flow than total numbers impinged during periods of high flow. Greater catches of queenfish were observed during periods of low and medium flow at night; however, no difference in abundance was observed under altering flow conditions during the day. Impingement of white croaker was significantly higher during periods of low and high flow than during medium flow.

FISH IMPINGES DURING HEAT TREATMENTS 1989-1995

Between November 1989 and December 1995, a total of 35 heat treatments were conducted at Scattergood Generating Station, where fish were identified to species (when possible), quantified, measured, weighed, and up to 50 individuals of some species were sexed. Between 1989 and 1991, a maximum of approximately 50 fish of each species was measured. Starting in 1992, a maximum of 200 fish of each species was measured. All 35 heat treatments started in the morning (0700-1015 hrs).

A total of 217,637 individuals, representing 79 species and weighing 13,744.8 kg, were accounted for at the 35 heat treatments (Appendix E).

Seventeen species, representing 11 families of fish, have been chosen as critical taxa for this study (Table 2.2). The fifteen most abundant fish observed at heat treatments between 1989 and 1995 were selected, as well as white seabass and California halibut for their commercial and recreational importance. These fish will be discussed in order of decreasing abundance.

This section utilizes fish length data to illustrate year classes of fish impinged. As a comparative tool, fish length data from two trawl programs (Scattergood Generating Station 1986 and 1988 NPDES monitoring and Hyperion Treatment Plant's marine monitoring program in 1990-1992, and 1994-1996) are also used. It should be noted that larger fish are more likely than smaller fish to avoid trawls.

Seasonal variations in size class were also examined. Fish impinged in "fall" were those impinged during September, October, and November 1989-1995. "Winter" refers to those fish impinged between December and February. Fish sampled between March and May were sampled in "spring," and fish impinged between June and August were impinged in "summer."

Trachurus symmetricus. Jack mackerel comprised 31.8% of total fish impinged at Scattergood Generating Station, with 69,195 individuals and a total weight of 2,258.8 kg (Table 2.3). Jack mackerel have been observed at only 20 heat treatments, however, and 90% (62,422 individuals) were impinged during one heat treatment (27 April 1994).

Spawning occurs inshore and offshore (Love 1991). Jack mackerel reach eight inches (203 mm SL) in their first year. Of the 515 fish measured at Scattergood Generating Station, most were younger than one year (Figure 2.16).

Seriphus politus. Queenfish rank second in heat treat abundance since 1989, with 38,479 individuals (17.7% of total abundance) (Table 2.3). Queenfish were present in 32 of the heat treatments conducted, and total biomass was 1,416.7 kg.

Queenfish spawn from March to August, and females mature at 100-105 mm SL (in their first spring or second summer following birth) (DeMartini and Fountain 1981). An analysis of the 3,026 queenfish measured at Scattergood Generating Station shows queenfish one to two years old were most frequently impinged (Figure 2.17). Analysis of fish impinged by size class and season shows juvenile queenfish are impinged more frequently in winter and spring (Figure 2.18). Figures 2.19 and 2.20 compare lengths of some queenfish impinged at Scattergood and lengths of fish caught in trawl surveys.

Table 2.3. The frequency, abundance, and biomass of critical taxa recorded during heat treatments at the Scattergood Generating Station 1989-1995.

SPECIES	No. of HTs* Present	NUMBER OF INDIVIDUALS Total No. Impinged	Avg/HT	Avg/Yr	BIOMASS (kg) Total	Avg/HT	Avg/Yr
Trachurus symmetricus	20	69195	1977.00	11862.00	2258.8	64.5	387.2
Seriphus politus	32	38479	1099.40	6596.40	1416.7	40.5	242.9
Atherinops affinis	27	24029	686.54	4119.26	1036.6	29.6	177.7
Atherinopsis californiensis	25	16820	480.57	2883.43	1817.9	51.9	311.6
Engraulis mordax	13	14561	416.00	2496.17	104.6	3.0	17.9
Sardinops sagax	23	10500	300.00	1800.00	543.3	15.5	93.1
Genyonemus lineatus	17	9063	258.94	1553.66	241.5	6.9	41.4
Xenistius californiensis	32	7770	222.00	1332.00	222.3	6.4	38.1
Umbrina roncador	23	5471	156.31	937.89	748.6	21.4	128.3
Hyperprosopon argenteum	27	3320	94.86	569.14	191.5	5.5	32.8
Anisotremus davidsonii	30	3179	90.83	544.97	1565.4	44.7	268.4
Scomber japonicus	19	3168	90.51	543.09	276.9	7.9	47.5
Paralabrax nebulifer	31	2296	65.60	393.60	972.3	27.8	166.7
Chromis punctipinnis	30	1714	48.97	293.83	183.1	5.2	31.4
Paralabrax clathratus	32	1322	37.77	226.63	470.3	13.4	80.6
Atractoscion nobilis	17	149	4.26	25.54	34.4	1.0	5.9
Paralichthys californicus	16	37	1.06	6.34	23.3	0.7	4.0
Sebastes spp.	22	189	5.4	32.4	20.0	0.6	3.4

*HT = Heat Treatment

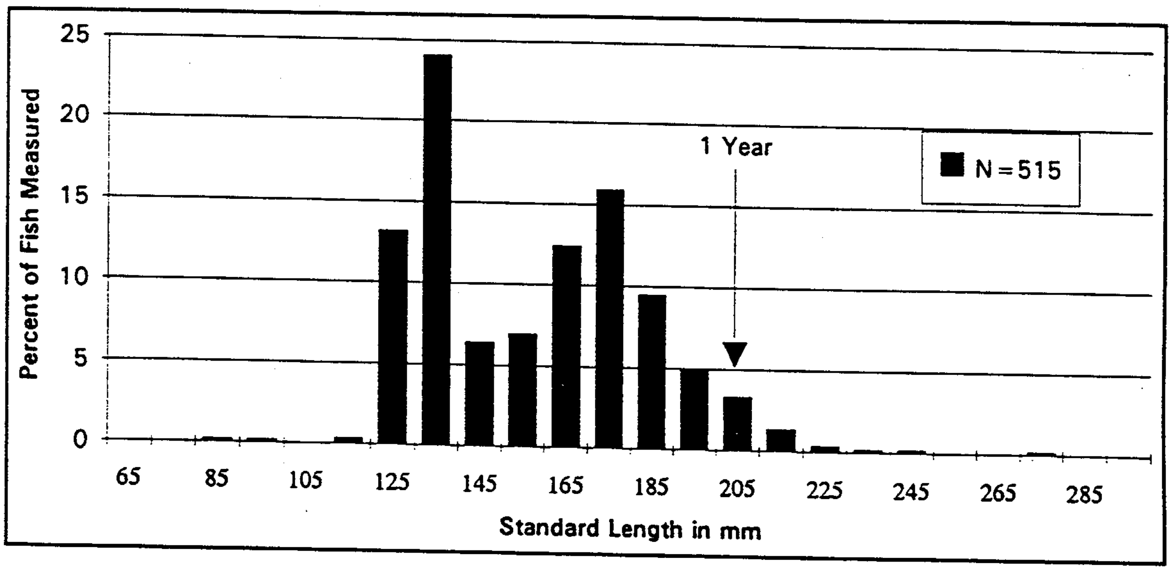

Figure 2.16. Length-frequency distribution of jack mackerel (*Trachurus symmetricus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

***Atherinops affinis*.** Topsmelt rank third in heat treat abundance, comprising 11% of fish impinged (24,029 individuals), and weighing a collective 1,036.6 kg (Table 2.3). Topsmelt have been observed at 27 heat treatments.

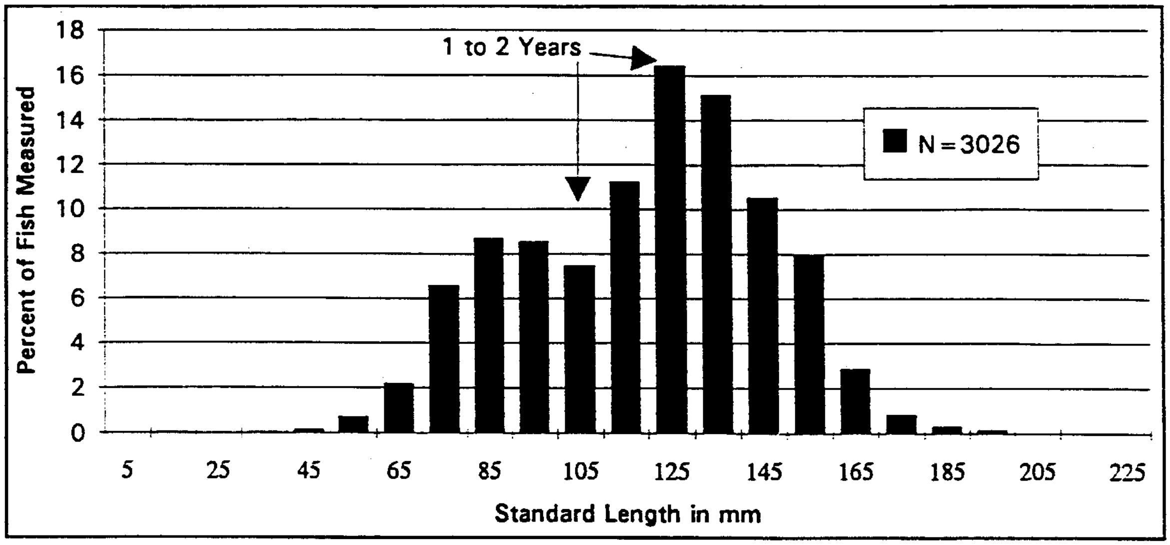

Figure 2.17. Length-frequency distribution of queenfish (*Seriphus politus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

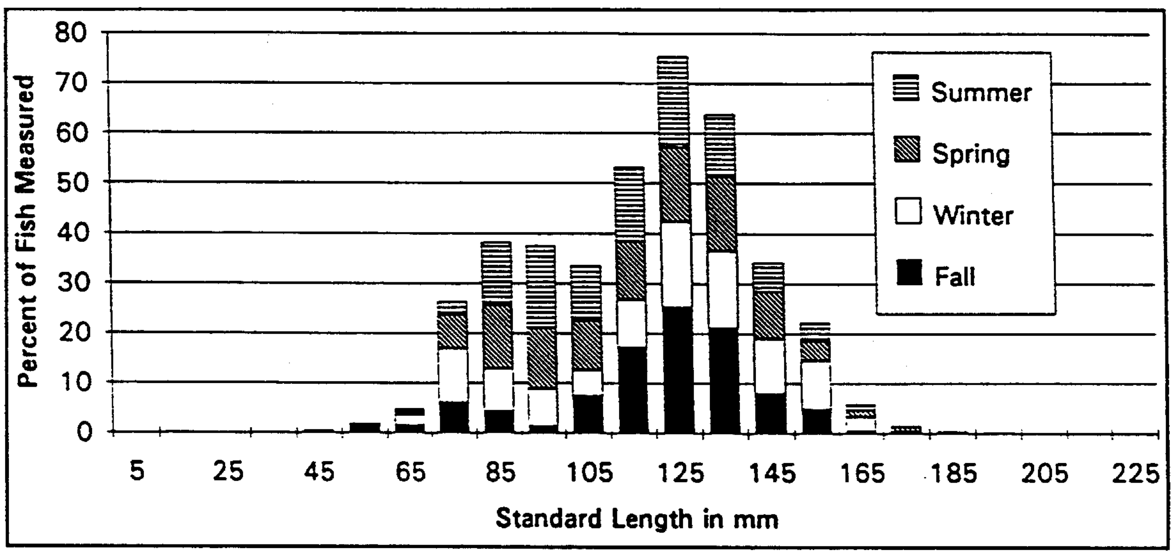

Figure 2.18. Seasonal length-frequency distribution of queenfish (*Seriphus politus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

Some topsmelt spawn at two years, most at three (Fitch and Lavenberg 1975). A 101 mm fish is probably one year old, and at two years is probably 152 mm SL (Love 1991). Figure 2.21 represents fish measured at Scattergood Generating Station (2,669 individuals). Most topsmelt impinged at Scattergood Generating Station were between 125 and 155 mm SL, corresponding to fish one to two years old.

***Atherinopsis californiensis*.** Jacksmelt rank fourth in overall heat treat abundance, and make up 7.7% of total impingement abundance (16,820 individuals) (Table 2.3). Jacksmelt also comprise 13% of total heat treatment biomass (1817.94 kg).

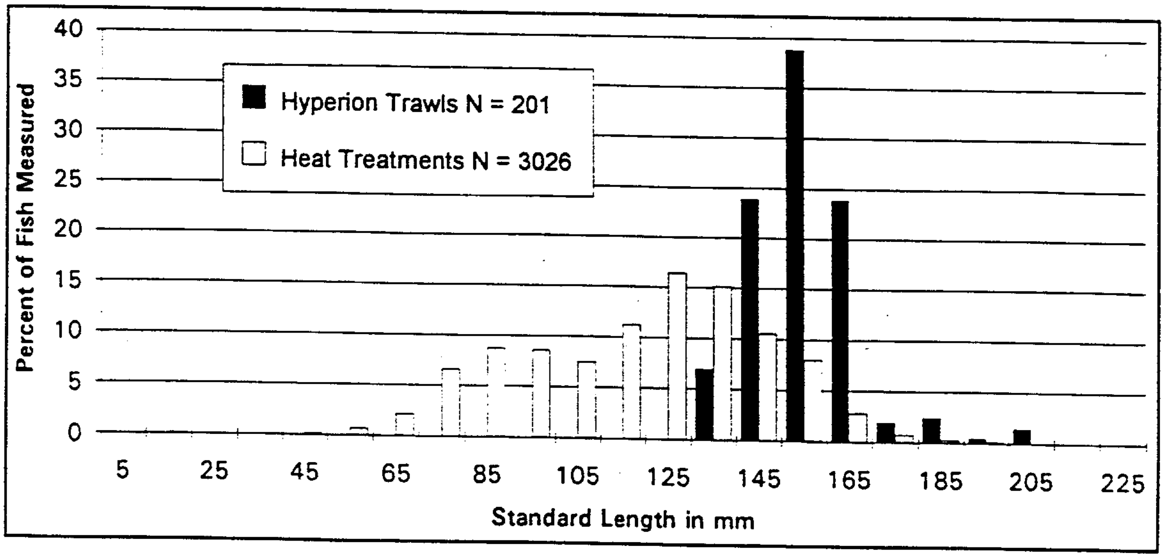

Figure 2.19. Comparison of length-frequency distributions of queenfish (*Seriphus politus*) measured during heat treatments at Scattergood Generating Station 1989-1995 and measured during Hyperion Treatment Plant NPDES demersal fish surveys 1990-1996.

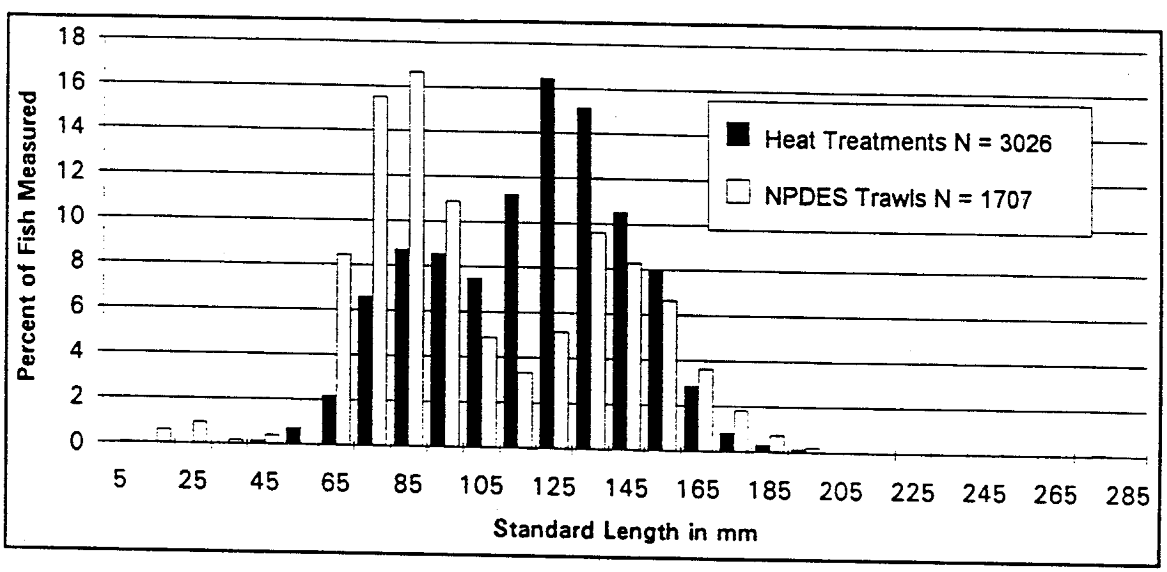

Figure 2.20. Comparison of length-frequency distributions of queenfish (*Seriphus politus*) measured during heat treatments 1989-1995 and during 1986 and 1988 Scattergood Generating Station NPDES demersal fish surveys.

Most jacksmelt mature at two years (152 to 203 mm SL) (Love 1991). Jacksmelt between 330 and 381 mm SL are probably eight to nine years (CDFG 1987). Measured fish lengths of 1,742 individuals are presented in Figure 2.22. Several size classes have been impinged by the Scattergood intake structure; most fish were probably one to four years old.

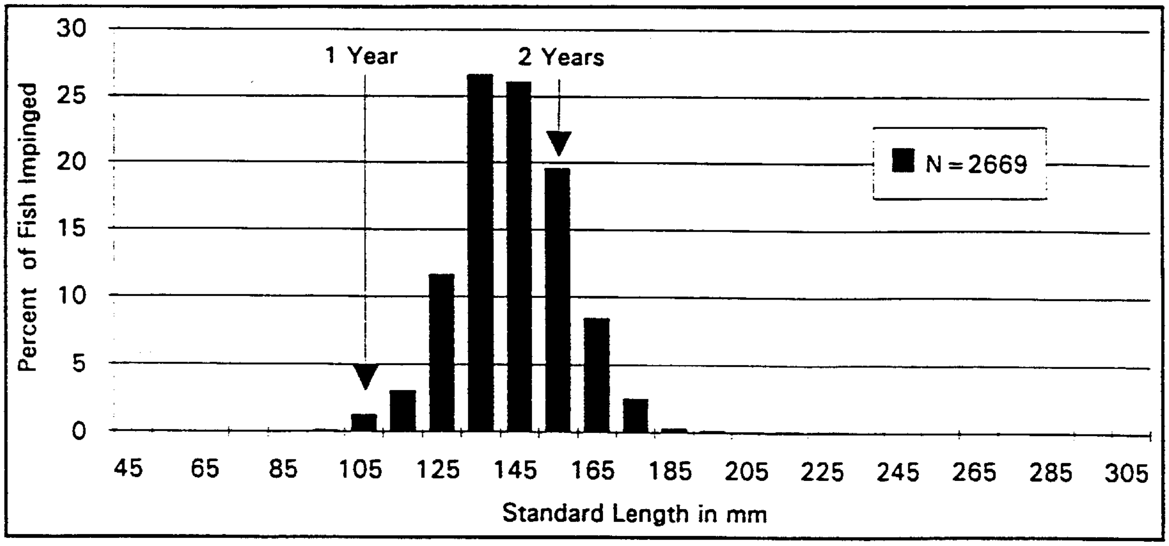

Figure 2.21. Length-frequency distribution of topsmelt (*Atherinops affinis*) measured during heat treatments at Scattergood Generating Station 1989-1995.

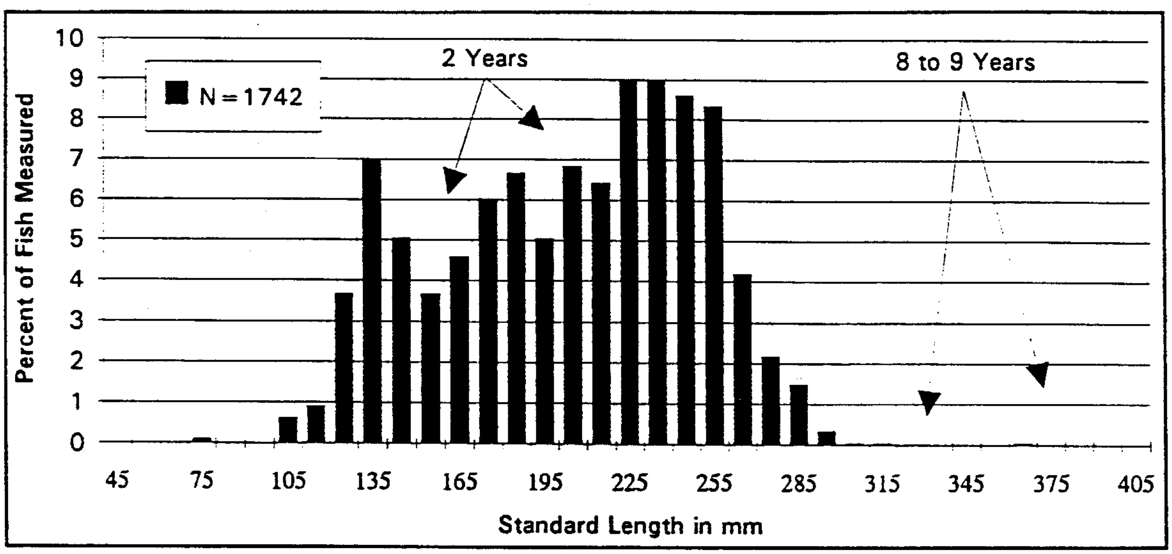

Figure 2.22. Length-frequency distribution of jacksmelt (*Atherinopsis californiensis*) measured during heat treatments at Scattergood Generating Station 1989-1995.

***Engraulis mordax*.** Although northern anchovy have been present at only 13 heat treatments, they rank fifth in abundance (14,557 individuals); 80% of these were impinged during one heat treatment (29 April 1992) (Table 2.3). Northern anchovy comprise 6.7% of total abundance. Total biomass of northern anchovy was 104.6 kg.

Northern anchovy reach 50 to 60 mm in their first two months, and mature when they are one to two years old and 78 to 140 mm long, and spawning occurs throughout the year (Sakagawa and Kimura 1976, MBC 1987). The California Department of Fish and Game studied size and age composition of commercially caught northern anchovy in the late 1960s. Analysis of otoliths and scales from northern anchovy caught on boats from San Pedro landings during the 1965-1966 and 1966-1967 seasons indicate Age 0 fish to be 78 to 126 mm SL, Age 1 fish to be 86 to 152 mm SL, and Age 2 fish to be 88 to 158 mm SL (Collins 1969). During the 1966-1967 season, the mean length of Age 0 fish was 100 mm SL, and the mean length of Age 1 fish was 115 mm; Age 2 anchovies averaged 122 mm.

Northern anchovy impinged at Scattergood Generating Station were most abundant in the 85 mm size class, corresponding to fish younger than two years old (Figure 2.23). Figure 2.24 compares lengths of some northern anchovy impinged at Scattergood Generating Station with lengths of trawl caught fish.

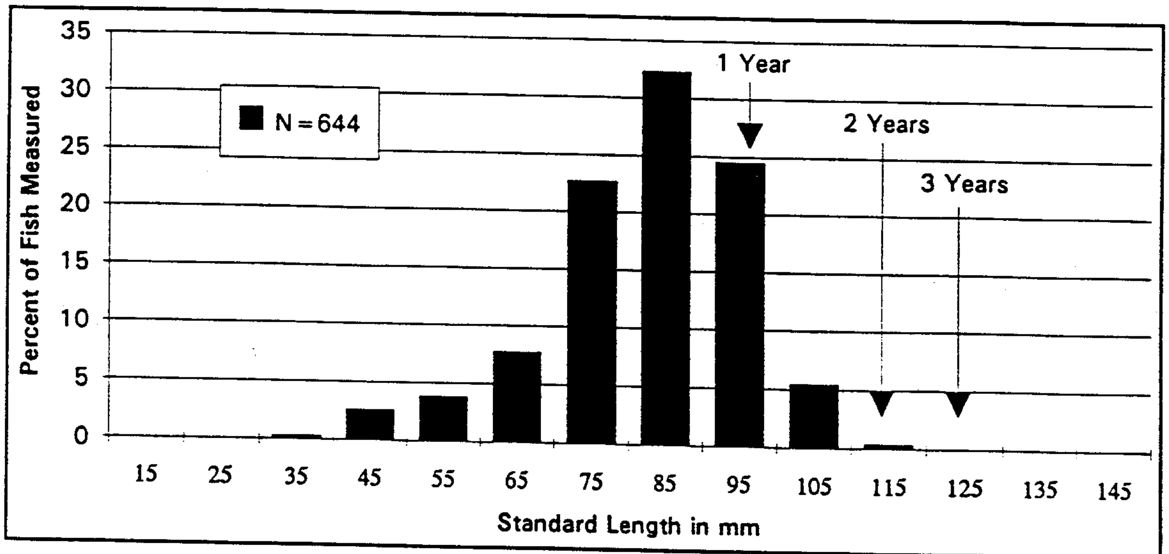

Figure 2.23. Length-frequency distribution of northern anchovy (*Engraulis mordax*) measured during heat treatments at Scattergood Generating Station 1989-1995.

***Sardinops sagax*.** Pacific sardine rank sixth in heat treat abundance, with 10,500 individuals (4.8% total abundance) collected at 23 heat treatments (Table 2.3). These fish weighed 543.3 kg.

A one-year-old Pacific sardine is 140 to 191 mm SL (Fitch and Lavenberg 1971). About 50% of Pacific sardines are mature at 178 to 203 mm, and most are mature at 241 mm (Love 1991). Adult spawning may take place two or three times per season (Fitch and Lavenberg 1971). Commercially caught Pacific sardines from southern California were examined for age determination by the California Department of Fish and Game between 1941 and 1947 (Phillips 1948). For Pacific sardines landed at San Pedro, scientists determined mean standard lengths for each year class: Age 0 = 152 mm, Age 1 = 184 mm, Age 2 = 198 mm, Age 3 = 205 mm. Pacific sardines measured at Scattergood Generating Station (1,266 individuals) are shown in Figure 2.25, along with estimated size classes. A mode at 165 mm SL is predominant, which coincides with young-of-the-year to one-year old fish.

***Genyonemus lineatus*.** White croaker were impinged at 17 heat treatments, and were represented by 9,063 individuals (4.2% total abundance) (Table 2.3). White croaker biomass totalled 241.5 kg.

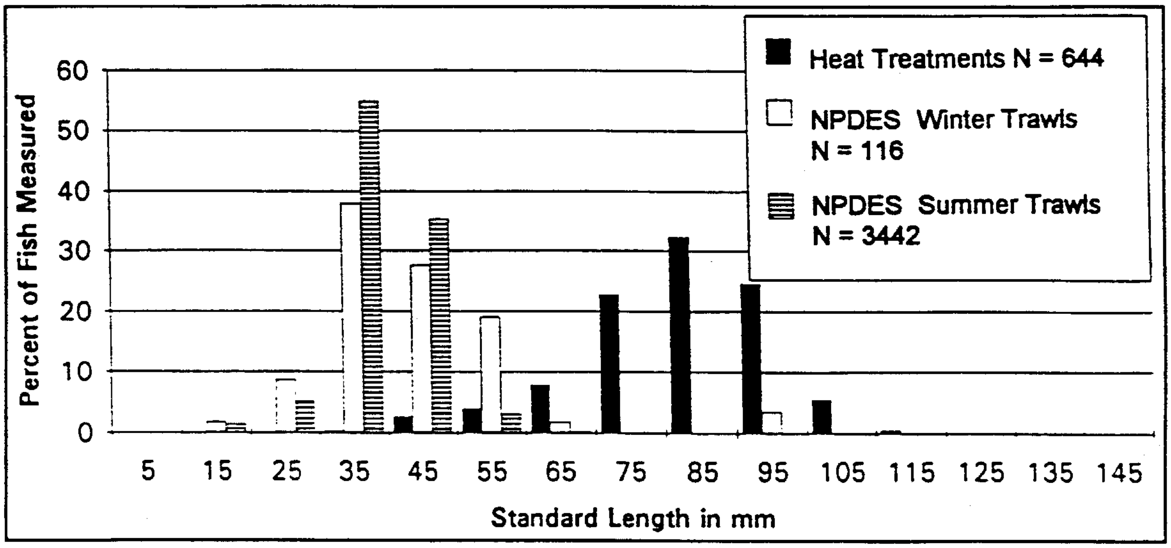

Figure 2.24. Comparison of length-frequency distributions of northern anchovy (*Engraulis mordax*) measured during heat treatments 1989-1995 and measured during 1986 and 1988 Scattergood Generating Station NPDES demersal fish surveys.

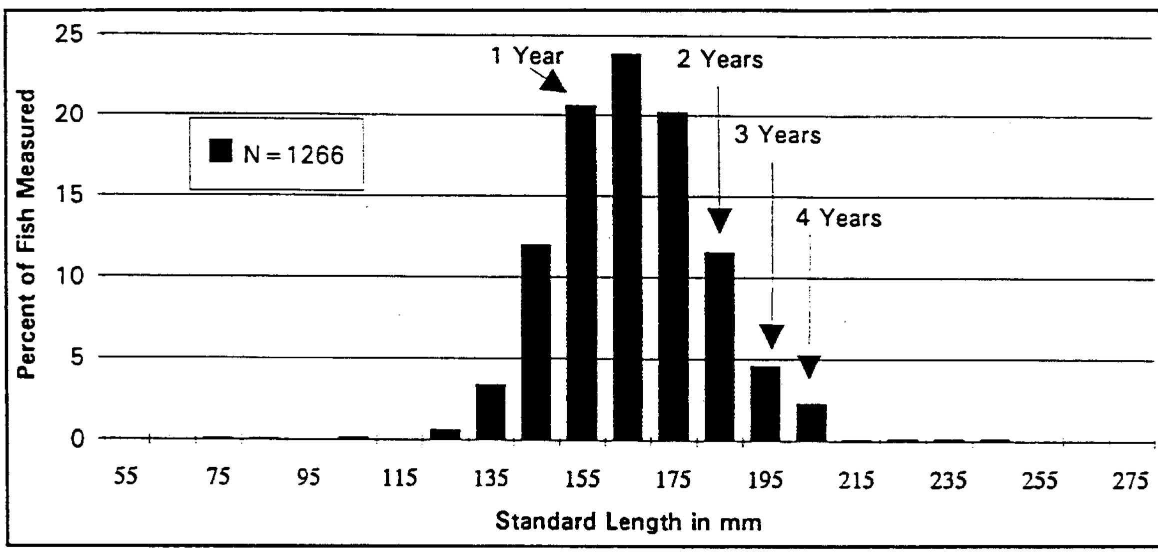

Figure 2.25. Length-frequency distribution of Pacific sardine (*Sardinops sagax*) measured during heat treatments at Scattergood Generating Station 1989-1995.

White croaker spawn throughout the year, but principal spawning appears to take place between November and April, with most activity in February-March (Love et al. 1984). Some white croaker mature before one year (129 to 134 mm TL), and most fish are mature by 190 mm TL. A two- to three-year old fish is 127 to 152 mm (CDFG 1987). A length-frequency histogram of white croaker measured at Scattergood Generating Station (842 individuals) is presented in Figure 2.26. Two distinct modes, one at 75 mm SL and one at 155 mm SL, are present. The mode occurring at 75 mm SL corresponds to young-of-the-year white croaker, the majority of which were impinged in the early summer of 1994. The second mode at 155 mm represents two-to three-year old fish. Figure 2.27 compares seasonal differences in size-classes; it appears most young-of-the-year white croaker are impinged during summer months.

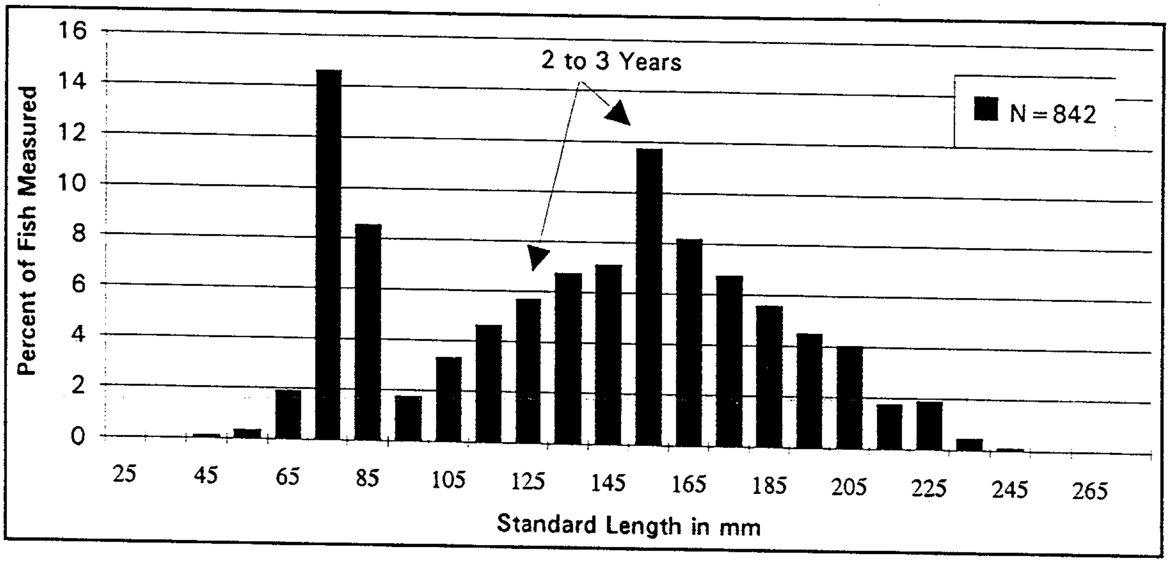

Figure 2.26. Length-frequency distribution of white croaker (*Genyonemus lineatus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

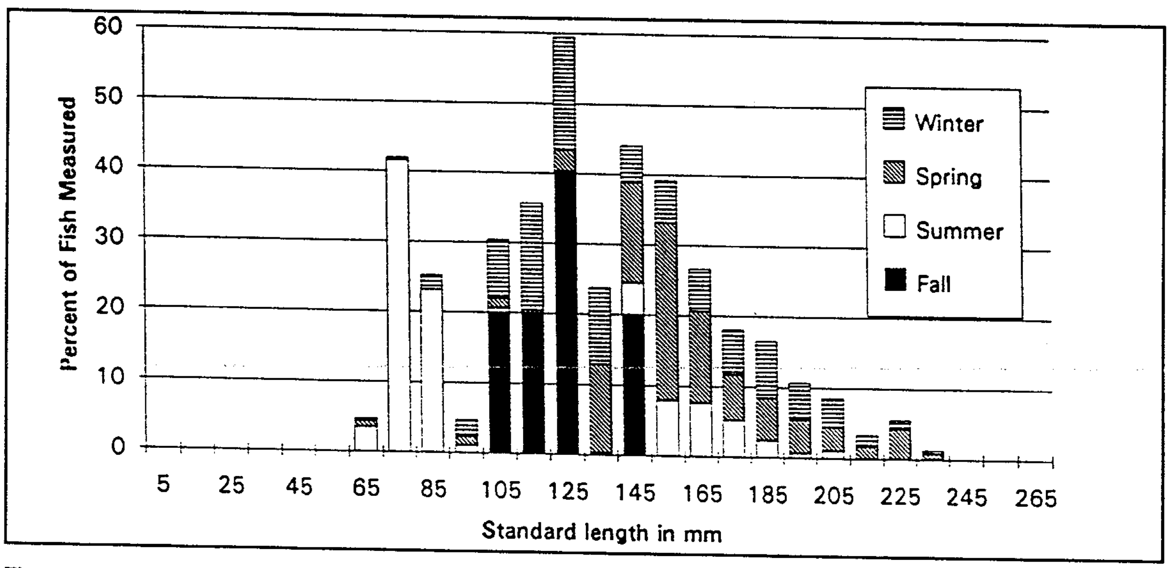

Figure 2.27. Seasonal length-frequency distribution of white croaker (*Genyonemus lineatus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

Figures 2.28 and 2.29 compare fish lengths of some white croaker impinged at Scattergood Generating Station and trawl caught fish.

***Xenistius californiensis*.** Salema rank eighth in heat treat abundance (7,770 individuals) and make up 3.6% total abundance (Table 2.3). Salema were present at 32 heat treatments and weighed 222.3 kg.

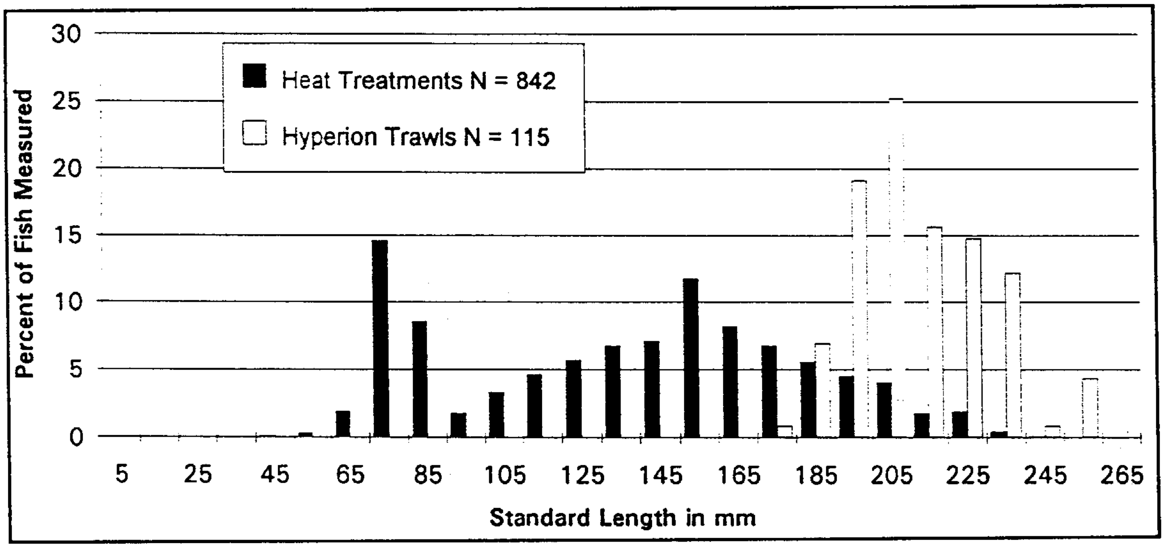

Figure 2.28. Comparison of length-frequency distributions of white croaker (*Genyonemus lineatus*) measured during heat treatments at Scattergood Generating Station 1989-1995 and measured during Hyperion Treatment Plant NPDES demersal fish surveys 1990-1996.

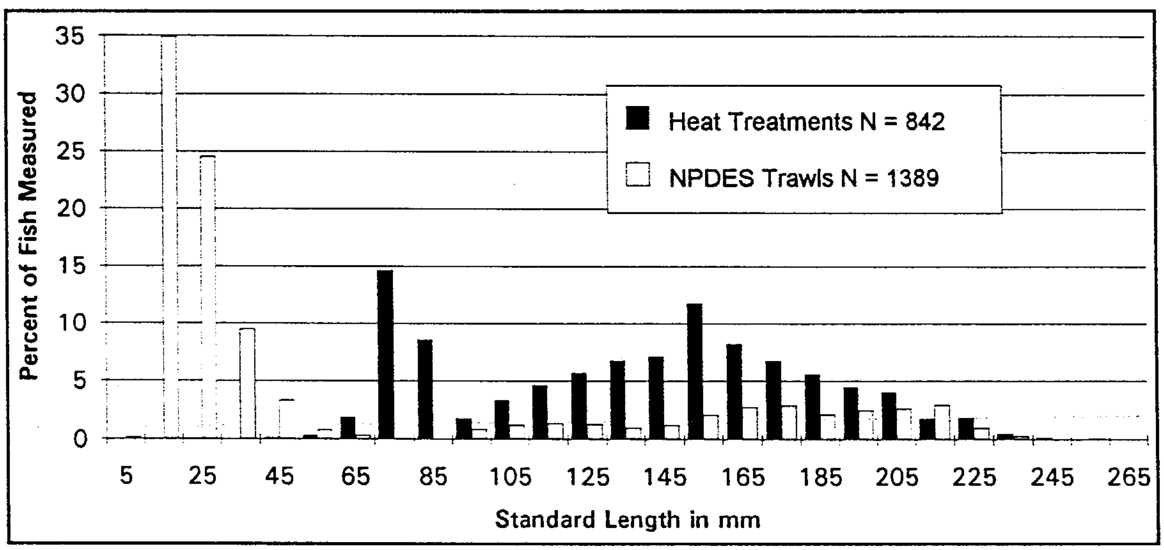

Figure 2.29. Comparison of length-frequency distributions of white croaker (*Genyonemus lineatus*) measured during heat treatments at 1989-1995 and during 1986 and 1988 Scattergood Generating Station NPDES demersal fish surveys.

Little is known about age-length relationships with this species (in an aquarium, a fish of one year measured 89 mm) (Fitch and Lavenberg 1975). Of the 7,770 salema impinged at Scattergood Generating Station, 2,273 have been measured; these data are presented in Figure 2.30.

***Umbrina roncador*.** Yellowfin croaker were observed at 23 heat treatments, and comprised 2.5% total abundance (5,471 individuals) (Table 2.3). Yellowfin croaker rank ninth in abundance and seventh in biomass (748.6 kg).

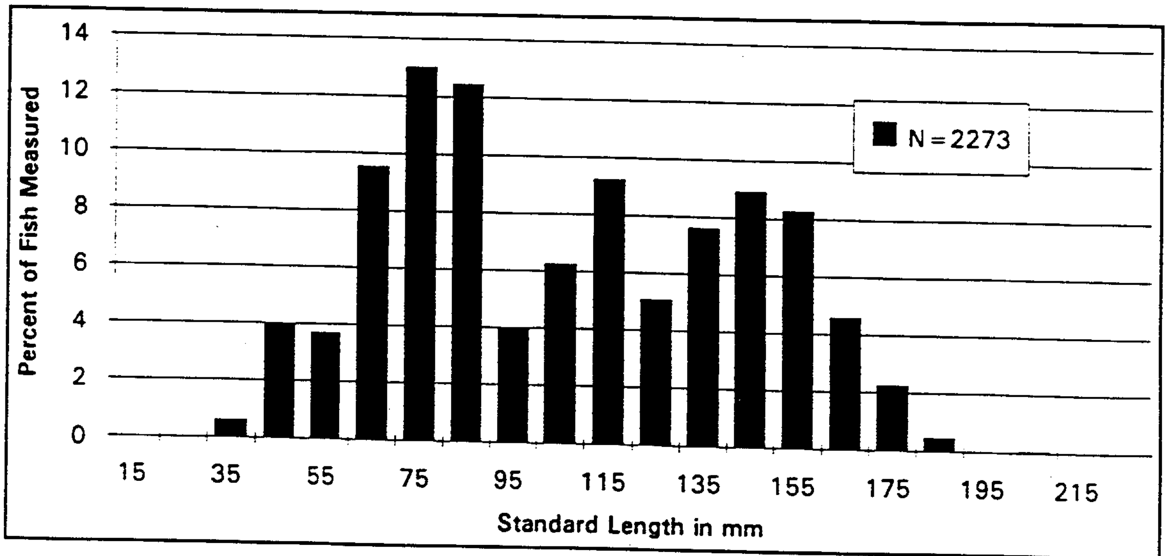

Figure 2.30. Length-frequency distribution of salema (*Xenistius californiensis*) measured during heat treatments at Scattergood Generating Station 1989-1995.

Yellowfin croaker mature at around 229 mm, and spawning generally occurs in the summer (Love 1991). Figure 2.31 is a length-frequency histogram for the 1,087 fish measured at Scattergood Generating Station. The peak at 115 mm SL is probably representative of fish one year old or younger. The mode centered at 215 mm SL may represent fish two to three years old. The small mode present at 415 mm SL corresponds to fish approximately ten years old (Love 1991).

***Hyperprosopon argenteum*.** Walleye surfperch rank tenth in heat treat abundance, with 3,320 individuals impinged and collectively weighing 191.5 kg (Table 2.3). Walleye surfperch were present during 27 heat treatments.

Most fish mature by their first year, about 114 mm (Love 1991). A four-year old is about 178 mm. Length-frequencies of 1,337 walleye surfperch impinged at Scattergood Generating Station are presented in Figure 2.32. The mode at 115 mm SL represents fish approximately one year old.

***Anisotremus davidsonii*.** Sargo were present at 30 of the 35 heat treatments, and rank eleventh in abundance with 3,179 individuals (Table 2.3). Sargo ranked third in total biomass, weighing 1,565.4 kg.

Sargo mature at about two years or 177 mm (Love 1991). Figure 2.33 presents length-frequency data of 1,187 sargo impinged at Scattergood Generating Station. The mode present at 245 mm SL corresponds with three- to four-year old fish. A large number of fish impinged are probably four to ten years old.

***Scomber japonicus*.** Chub mackerel were present at 19 heat treatments; 3,168 individuals were impinged (Table 2.3).

Spawning usually peaks between March and May; most fish spawn at two years, and all at three (Fitch and Lavenberg 1971). All of the fish impinged appear to be less than three years (Figure 2.34; MBC 1987).

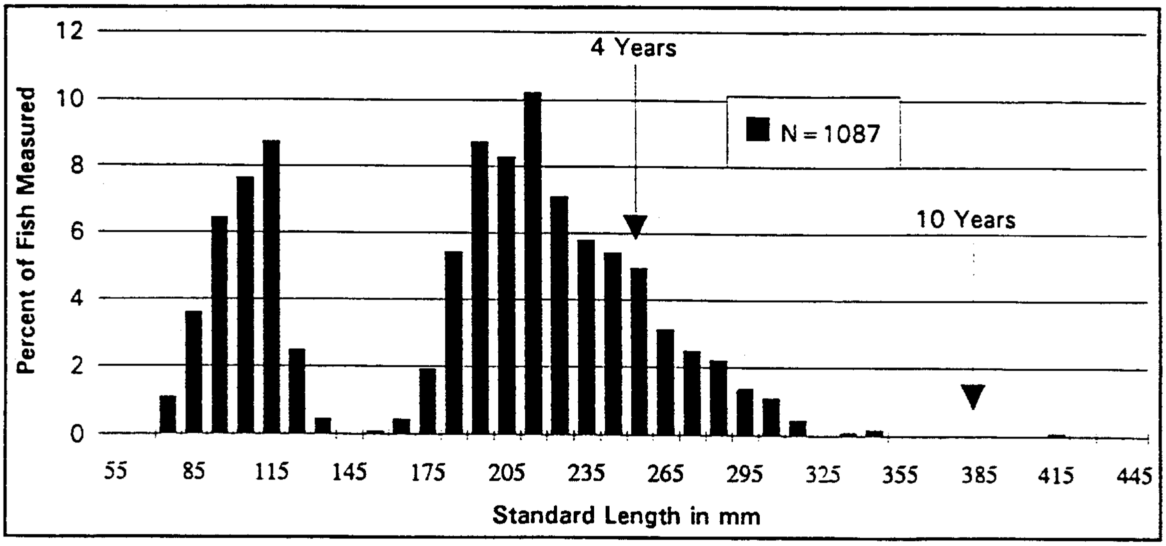

Figure 2.31. Length-frequency distribution of yellowfin croaker (*Umbrina roncador*) measured during heat treatments at Scattergood Generating Station 1989-1995.

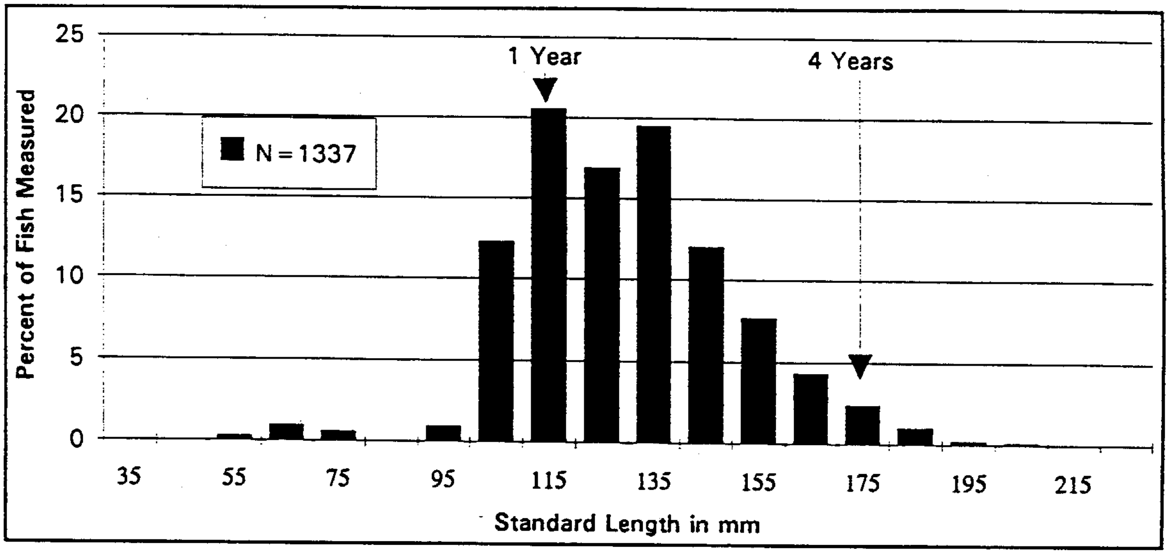

Figure 2.32. Length-frequency distribution of walleye surfperch (*Hyperprosopon argenteum*) measured during heat treatments at Scattergood Generating Station 1989-1995.

***Paralabrax nebulifer*.** Barred sand bass were observed during 31 heat treatments (Table 2.3). They rank thirteenth in abundance (2,296 individuals) and sixth in biomass (972.3 kg).

Sand bass mature at around 229 mm (Love 1991). Spawning occurs during late spring and summer months, and form large aggregations during this time (Leet et al. 1992). Analysis of fish measured at Scattergood Generating Station shows most fish in the one- to four-year range (Figure 2.35).

***Chromis punctipinnis*.** Blacksmith rank fourteenth in total heat treat abundance (1,714 individuals) (Table 2.3). They were seen at 30 heat treatments.

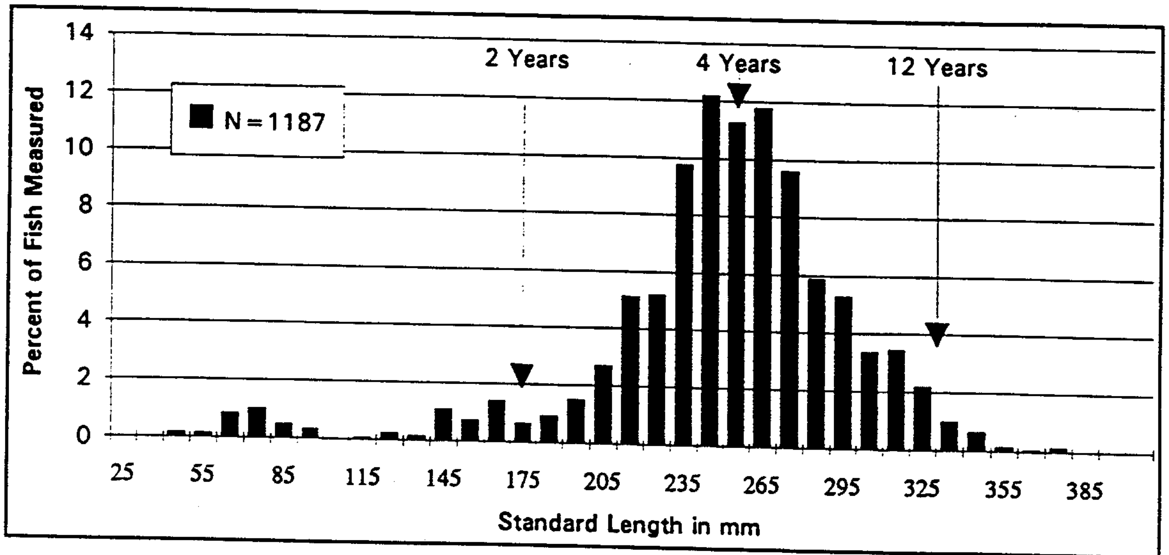

Figure 2.33. Length-frequency distribution of sargo (*Anisotremus davidsonii*) measured during heat treatments at Scattergood Generating Station 1989-1995.

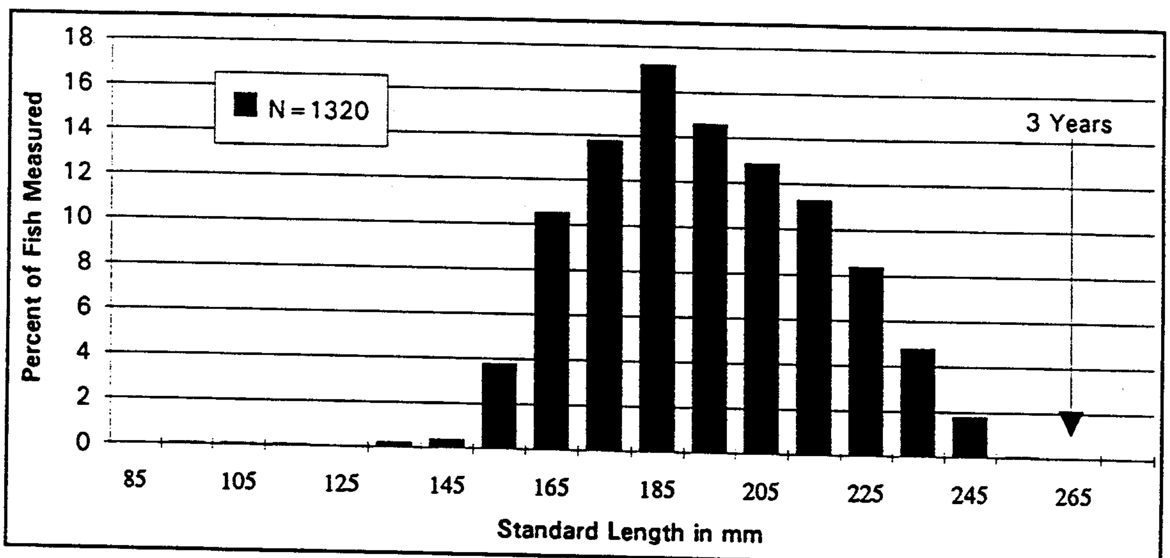

Figure 2.34. Length-frequency distribution of chub mackerel (*Scomber japonicus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

These fish probably mature at around 140 mm (two years)(Love 1991). Spawning occurs in summer and newly recruited juveniles appear in late summer and early fall. Figure 2.36 represents length-frequencies of 938 blacksmith impinged at Scattergood Generating Station. Figure 2.37 compares seasonal length-frequencies of blacksmith. The higher abundance of juvenile blacksmith in the fall agrees with known spawning patterns.

***Paralabrax clathratus*.** Kelp bass comprise less than 1% of total abundance (0.61%), with 1,322 individuals, and were present at 32 of the 35 heat treatments (Table 2.3).

Spawning occurs from May through November, with a summer peak in July (CDFG 1987). Some kelp bass mature at around 178 mm, or two to three years, and the rest later on (Love

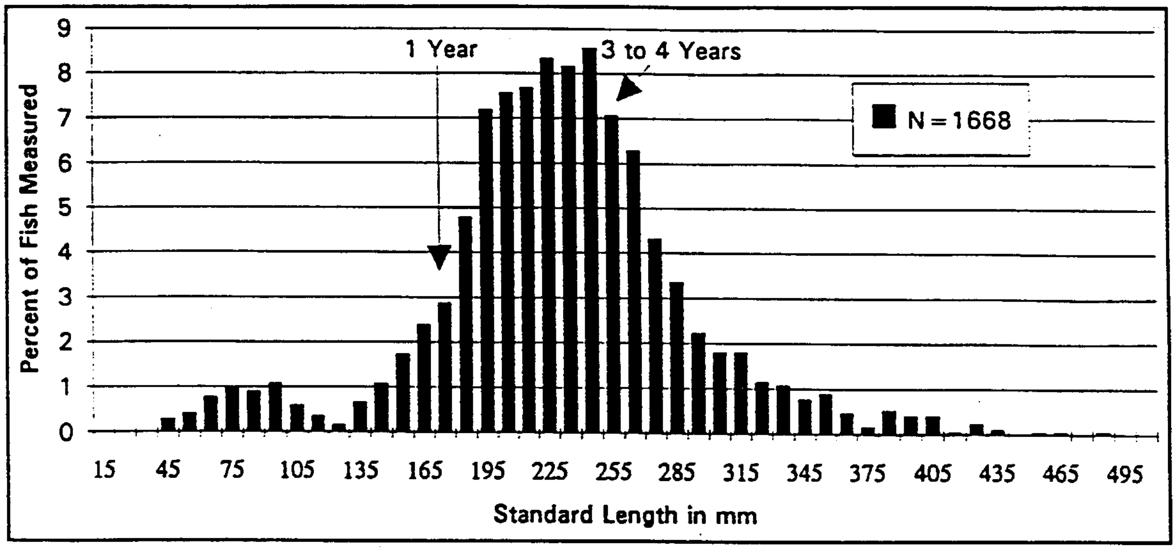

Figure 2.35. Length-frequency distribution of barred sand bass (*Paralabrax nebulifer*) measured during heat treatments at Scattergood Generating Station 1989-1995.

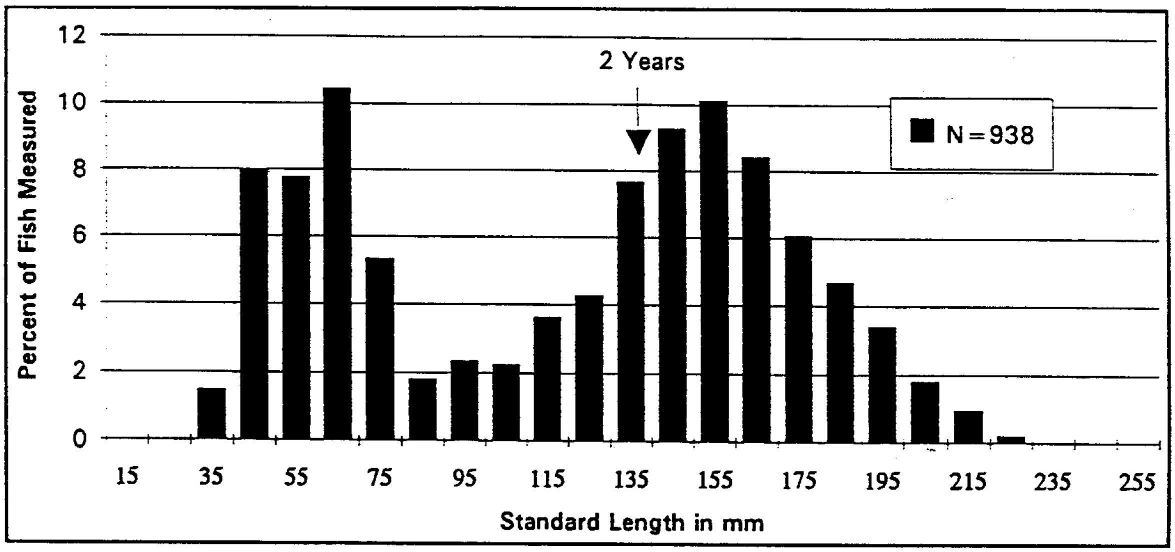

Figure 2.36. Length-frequency distribution of blacksmith (*Chromis punctipinnis*) measured during heat treatments at Scattergood Generating Station 1989-1995.

1991). By five years (about 267 mm), nearly all are capable of reproducing (CDFG 1987). Kelp bass observed at Scattergood Generating Station range from young-of-the-year to around eight years old (Figure 2.38) (Love 1991).

Atractoscion nobilis. White seabass were observed at 17 heat treatments, and 150 individuals were impinged (Table 2.3). Total biomass for impinged *Atractoscion* was 34.36 kg.

White seabass spawn from late spring through summer (Fitch and Lavenberg 1971). About 50% of males are mature at 609 mm; half of females are mature at 711 mm (Love 1991). At the minimum catch length of 28 in. (711 mm), a white seabass has lived approximately five

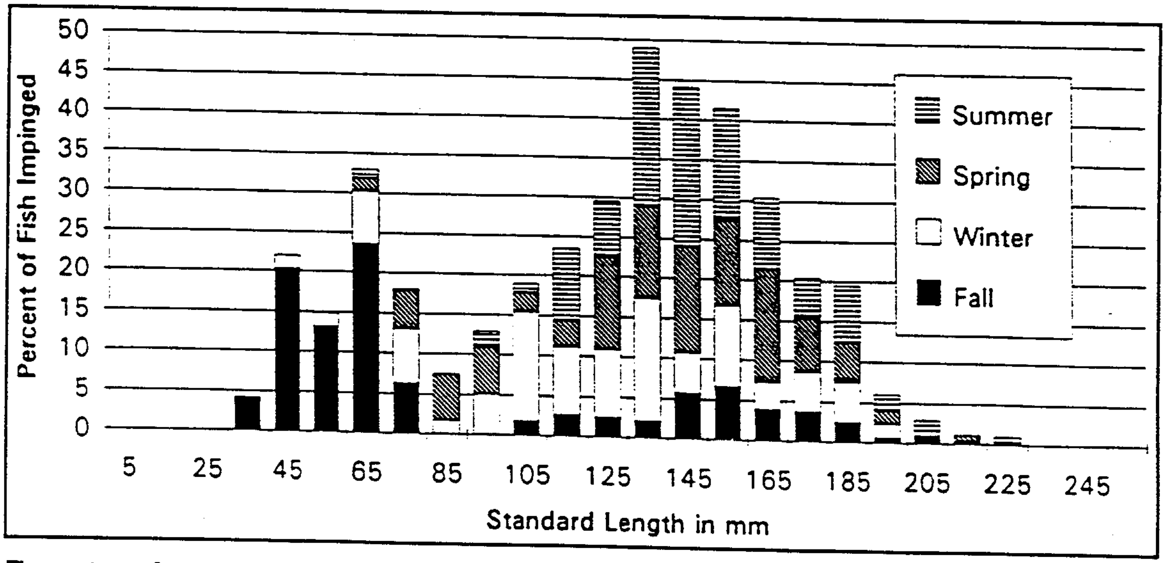

Figure 2.37. Seasonal length-frequency distribution of blacksmith (*Chromis punctipinnis*) measured during heat treatments at Scattergood Generating Station 1989-1995.

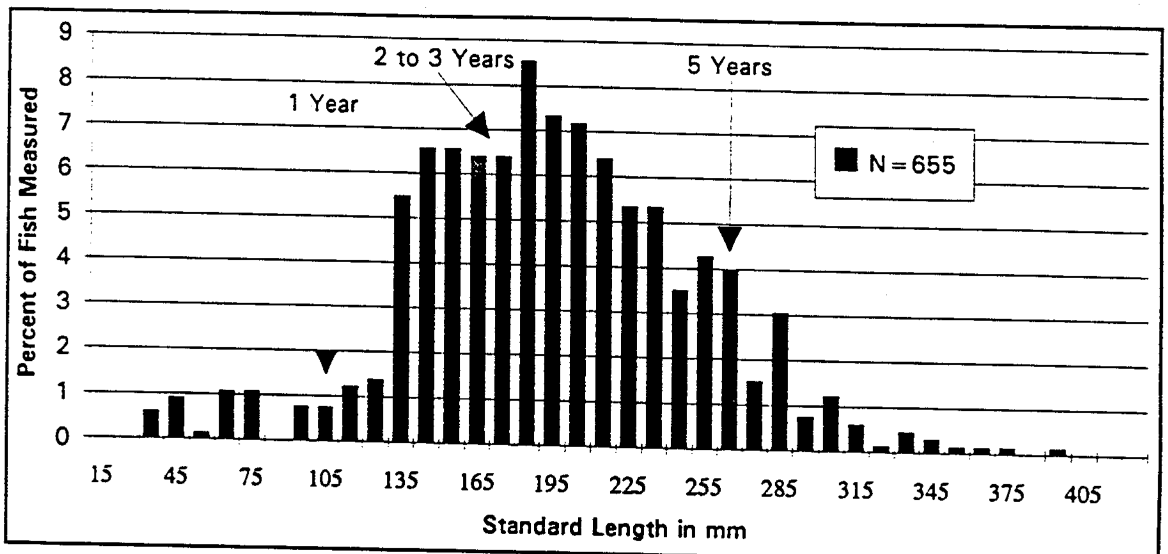

Figure 2.38. Length-frequency distribution of kelp bass (*Paralabrax clathratus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

years (CDFG 1987). It is not likely that any of the 146 white seabass impinged at Scattergood Generating Station were mature (Figure 2.39).

Paralichthys californicus. Only 37 California halibut have been impinged between 1989 and 1995 (Table 2.3). These fish weighed 23.34 kg, and were present at 16 heat treatments.

All males are mature at two to three years; females at four years (Fitch and Lavenberg 1971). Spawning occurs in shallow waters (6 to 20 m) over sandy bottoms (MBC 1987). The distribution of the 32 halibut measured at Scattergood Generating Station is fairly even (Figure 2.40). At one year, a California halibut is approximately 179 mm (Love 1996). Figures 2.41 and

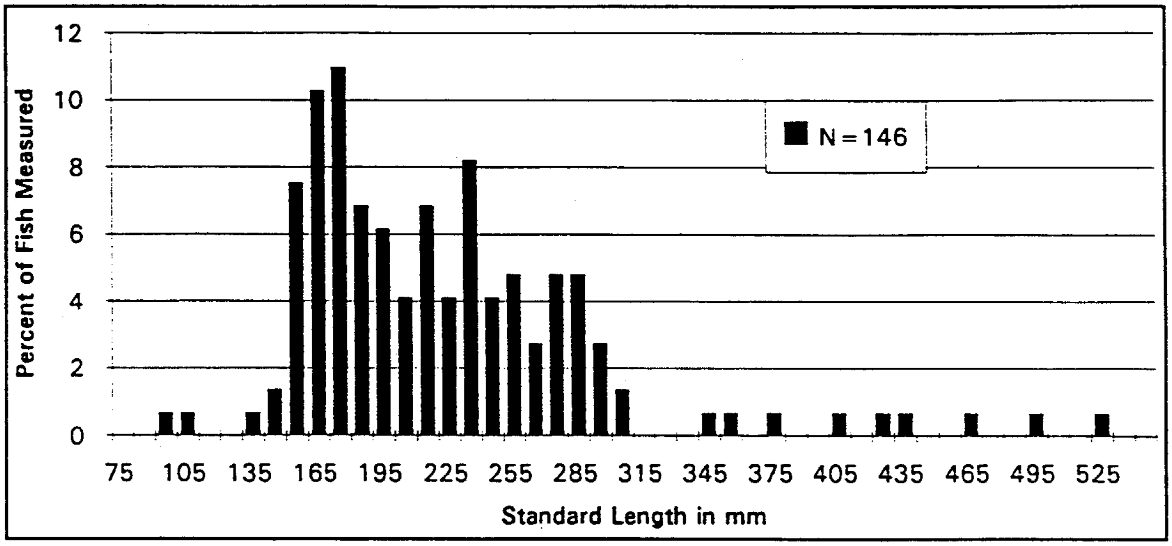

Figure 2.39. Length-frequency distribution of white seabass (*Atractoscion nobilis*) measured during heat treatments at Scattergood Generating Station 1989-1995.

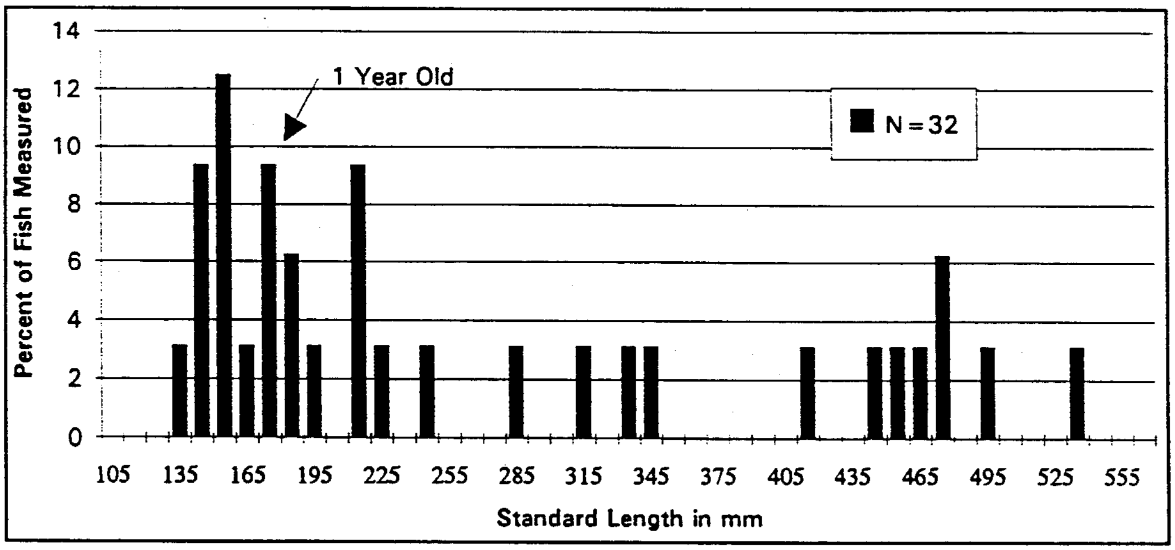

Figure 2.40. Length-frequency distribution of California halibut (*Paralichthys californicus*) measured during heat treatments at Scattergood Generating Station 1989-1995.

2.42 compare fish lengths of some halibut measured at Scattergood Generating Station with trawl caught fish.

INTERRELATIONSHIP OF PHYSICAL, OCEANOGRAPHIC, AND GENERATING STATION EFFECTS

This section examines the interrelationship of the nearshore marine ecosystem and effects of the Scattergood Generating Station cooling water intake system. Comparisons are made between conclusions of the 1981 316(b) demonstration and the review of data collected since then.

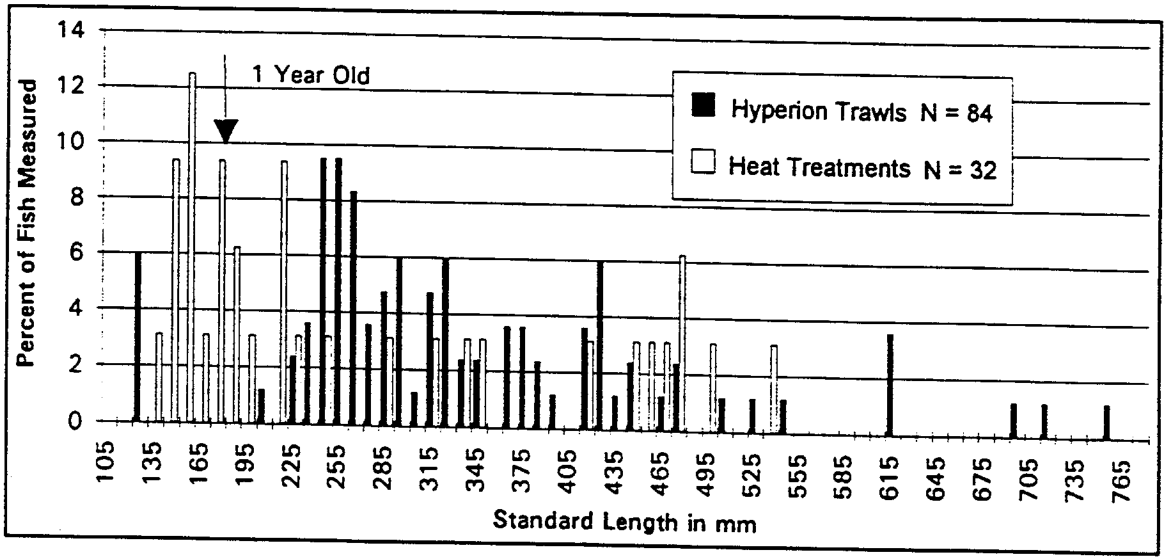

Figure 2.41. Comparison of length-frequency distributions of California halibut (*Paralichthys californicus*) measured during heat treatments at Scattergood Generating Station 1989-1995 and measured during Hyperion Treatment Plant NPDES demersal fish surveys 1990-1996.

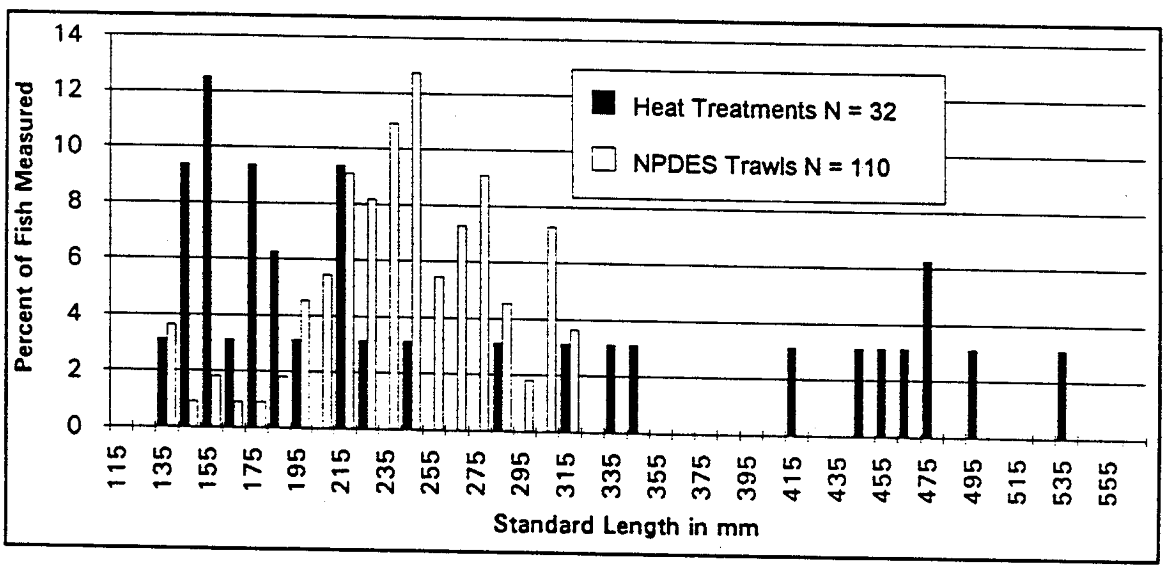

Figure 2.42. Comparison of length-frequency distributions of California halibut (*Paralichthys californicus*) measured during heat treatments 1989-1995 and during 1986 and 1988 Scattergood Generating Station NPDES demersal fish surveys.

This study examines the existence or non-existence of a relationship between impingement of fish at the Scattergood Generating Station and physical and oceanographic effects not discussed in the first 316(b) evaluation, such as seasonality and storm activity. Sea surface temperatures (1989-1995) will be examined to determine if critical fish species impinged are more abundant during different seasons. Also, by examining wave heights and days of rainfall between heat treatment operations, it will be determined if critical fish species are more turbidity.

susceptible to impingement during periods of possible increased current speeds and water turbidity. Also analyzed are intake flow and period between heat treatments.

Methods

Correlations between impingement of fish and sea surface temperature (seasonality), sea state (wave height), days of rain, days between heat treatments, and Generating Station effects (intake flow) were examined (Appendix G). Daily Santa Monica Bay sea surface temperatures (SSTs) were obtained from a station at the Santa Monica Pier (Nemo 1996). Wave height data (1992-1995) from the shoreline in the immediate vicinity of the Scattergood Generating Station intake structure were obtained from Los Angeles County lifeguards (LACL 1996, unpubl. data). Maximum surf height was recorded daily by lifeguards, and these data were used to compare sea state and Scattergood Generating Station fish impingement. L.A. County lifeguards also recorded days of rainy conditions. Data from lifeguards dates back to 1992, so these are used in comparisons of only 21 heat treatment operations. Circulating water flow data (1982-1995) were obtained from the Los Angeles Department of Water and Power and entered in a spreadsheet program (Lotus 1-2-3).

The above parameters were subjected to regression analysis using Excel 4.0. The r-value generated by this method is used as a comparative tool to express the degree of correlation between two or more variables. An r-value of 1.0 denotes a positive correlation (both variables increase or decrease together), an r-value of 0 denotes no relationship, and an r-value of -1.0 denotes a negative correlation (one variable increases as the other decreases). A correlation (positive or negative) is deemed significant if it has a corresponding F-value less than 0.05. Correlation calculations and graphs are presented in Appendix G.

Source Water Characteristics

Distribution of marine life in the source waters of the Scattergood Generating Station may vary, depending on several factors.

Phytoplankton are the basis of the marine food chain, converting inorganic material to organic matter via photosynthesis. All marine life ultimately depends on photosynthesis; zooplankton feed on phytoplankton, fish and other invertebrates feed on zooplankton, etc. All of these organisms are eventually recycled by decomposers (usually on the sea floor). In Santa Monica Bay, generally between March and June, upwelling brings colder, nutrient-rich waters to the euphotic zone. During these times, phytoplankton blooms are common nearshore with coinciding increases in zooplankton and other organisms.

Offshore Scattergood Generating Station, the most commonly occurring direction for subtidal-frequency nearshore drift is approximately 156°T (longshore and downcoast of the generating station) (Figure 2.4) (IRC 1981a). A downcoast displacement of approximately 119 m (390 ft) occurs each tidal period (0.26 day), when tidal forces displace water approximately 810 m (2,658 ft) in each longshore direction (IRC 1981a).

Dye studies done during the 1981 demonstration showed the time-averaged zone of the 50% probability of entrainment isopleth is nearly circular and has a radius of 14 m (46 ft) on the center of the intake riser (IRC 1981a). At that distance, ocean currents and plant induced velocities are in approximate balance.

Habitat Preference

Distribution of marine life, and the extent to which certain species are affected by the intake structure, is also dependent on habitat preferences. The nearshore zone in the vicinity of Scattergood Generating Station provides several habitat types. Vast expanses of sand are common; however, the Scattergood Generating Station intake and discharge structures, as well as other submerged structures throughout the area, provide alternate habitat. Marina del Rey, located upcoast from the generating station, is considered a bay environment.

Zooplankton

The copepod *Acartia* is a cosmopolitan species, inhabiting bays, estuaries, and nearshore waters throughout most of the world. Entrainment effects on this species would be diluted over a large area having a longshore configuration within the neritic waters of southern California.

Neomysis kadiakensis is the only mysid studied considered an "open-water" species, not choosing bays and estuaries as its primary habitat. Entrainment effects on this species are likely seen as small depletions over a very large area (the Southern California Bight). *Acanthomysis macropsis*, *Metamysidopsis elongata*, and *Mysidopsis* spp. are inshore species, but entrainment effects on these taxa will be less important throughout Santa Monica Bay than in a smaller bay area.

Cancer spp. zoeae are often associated with rock structures along the open coast or outer bays. Entrainment losses of this species will effect populations downcoast and offshore of Scattergood Generating Station, which depend upon recruitment from upcoast areas.

Zoeae of the sand crab *Emerita analoga* are more common offshore than inshore, and this will result in less entrainment.

Fish

The sciaenids white croaker, queenfish, white seabass, and yellowfin croaker are common throughout the Southern California Bight in open coast and bay environments. Spawning occurs over a large area, and extremely high fecundity and high natural mortality rates for larvae of these taxa are common. Local magnitude of impingement effects would be very limited. Impingement of large numbers of white seabass, however, may be more noticeable, as populations of this fish are presumably smaller.

Open-water schooling fishes such as jack mackerel, Pacific sardine, and chub mackerel are distributed throughout the Southern California Bight as well, and the area around the intake is probably not their primary habitat; however, they may use this area to feed or school. Impingement of these fish is probably seen as minor depletions as well.

Jacksmelt, topsmelt, and salema usually occur in schools in a variety of habitats, including bays and estuaries, kelp beds, and sandy beaches. Jacksmelt have been observed at depths of 95 ft (Love 1991). It is unlikely fish impinged at Scattergood Generating Station are noticeable depletions to the population throughout the bay.

Fish that spend the majority of their time on the bottom are less likely to be affected by the currents associated with the elevated intake riser at Scattergood Generating Station, such as

California halibut. Other fish which spend considerable time on the sea floor, but disperse to feed in the water column, such as barred sand bass, will be susceptible to impingement at times.

Fishes associated with underwater structures (kelp bass, blacksmith, and sargo), probably use the intake structure as a foraging area as well as for primary habitat. Losses attributed to these fish are probably relatively small.

The surfperch, which also use the intake structure as a foraging area, are unlike any of the above mentioned fishes in that they are viviparous, and do not disperse eggs or sperm throughout the water column. Instead, fertilization is internal, and perch generally bear 10 to 30 individuals at one time. Impingement of these fishes probably has a more wide-ranging effect on the local population as a whole. Walleye surfperch is the surfperch examined in this study; females of this species produce up to 19 young.

Correlations of Impinged Critical Species with Environmental and Generating Station Factors

Seasonality - Sea Surface Temperature

Average Santa Monica Bay sea surface temperature between heat treatment operations ranged from 57°F to 70°F. Contained in Appendix G-1 are graphs and scatter diagrams of comparisons made. Some r-values suggest a significant positive correlation, such as the comparison of kelp bass abundance and sea surface temperature (SST) (Figure 2.43; r-value = 0.427, $F < 0.05$). Other significant positive correlations include sargo abundance and northern anchovy abundance with sea surface temperature ($r = 0.405$ and 0.349, respectively; Table 2.4). These positive r-values indicate increased abundance with increased sea surface temperatures, meaning higher abundance of these species with warmer water temperatures in spring and summer. The r-value of -0.540 ($F < 0.05$) suggests a significant negative correlation between impingement abundance of queenfish and SST (more individuals impinged with lower sea surface temperatures; Figure 2.44). Of the twenty parameters compared with SST (17 fish species, abundance, biomass, and number of species), there are eight positive correlations and 12 negative correlations.

Wave Height

Critical species abundance, total abundance, biomass, and number of species were compared with mean wave height between heat treatments (Appendix G-2). Mean wave heights between heat treatment operations ranged from 1.82 to 3.55 feet. Queenfish abundance demonstrates a significant positive correlation with mean wave height ($r = 0.447$, $F < 0.05$; Table 2.5). This indicates increased impingement of queenfish with higher mean wave heights (generally associated with storm activity). Increased wave heights associated with storms, and a concurrent increase in surge, can carry fish suddenly into areas of high velocity in the vicinity of the intake. Waves associated with increased storm activity can also resuspend sediments. This, along with stormwater runoff from land, can decrease water clarity. Of the twenty parameters compared with mean wave height, there are eight positive correlations and 12 negative correlations.

Days of Rain

Also associated with storm activity is number of days of rain between heat treatments. Days of rain between heat treatments at Scattergood Generating Station ranged from zero to 16 days. Correlation graphs between critical fish species abundance, total abundance and biomass, and number of fish species with days of rain are found in Appendix G-3. A significant positive

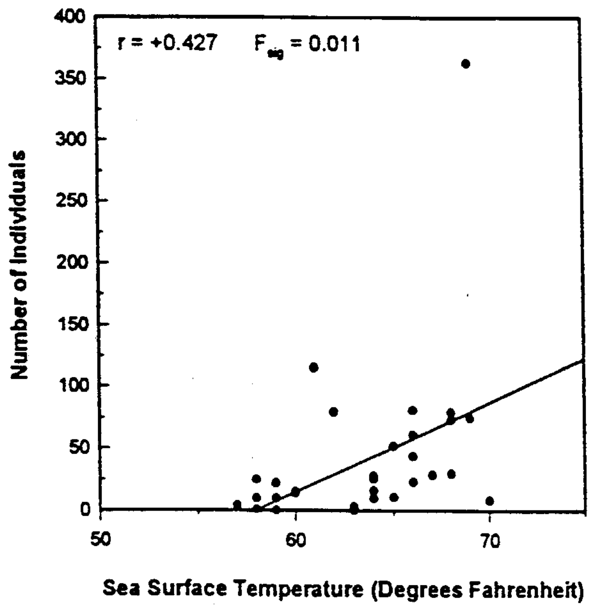

Figure 2.43. Scatter diagram of number of kelp bass (*Paralabrax clathratus*) measured during heat treatments at Scattergood Generating Station 1989-1995 and average Santa Monica Bay sea surface temperature since the last heat treatment.

Table 2.4. Correlations of mean sea surface temperature (SST) between heat treatments with 20 parameters.

Parameter	r-value	F-value
kelp bass	0.427	0.011*
sargo	0.405	0.016*
northern anchovy	0.349	0.040*
jacksmelt	0.210	0.654
blacksmith	0.108	0.226
white seabass	0.103	0.537
topsmelt	0.089	0.556
barred sand bass	0.079	0.610
biomass	-0.032	0.857
white croaker	-0.057	0.743
yellowfin croaker	-0.064	0.717
salema	-0.124	0.476
chub mackerel	-0.138	0.431
number of species	-0.176	0.311
California halibut	-0.181	0.299
abundance	-0.215	0.216
Pacific sardine	-0.221	0.201
jack mackerel	-0.232	0.179
walleye surfperch	-0.289	0.092
queenfish	-0.540	0.001*

*indicates significance at 0.05 level.

correlation between abundance of walleye surfperch impinged and days of rain between heat treatments is indicated ($r = 0.684$, $F < 0.05$), meaning higher walleye surfperch abundance with increased rain (Table 2.6). Of the twenty parameters compared with days of rain, there are eight positive correlations and 12 negative correlations.

Period Between Heat Treatments

Number of days between heat treatment operations at Scattergood Generating Station ranged from 14 to 128 days. An increase in the number of fish species impinged corresponds with an increase in the period between heat treatments ($r = 0.404$, $F < 0.05$) (Table 2.7). Other significant positive correlations are abundance of salema ($r = 0.380$) and walleye surfperch ($r = 0.360$), indicating increased abundance of these species with increased intervals between heat treatment operations. Of the twenty parameters compared with interval between heat treatments, there are 17 positive correlations and three negative correlations. Correlation data can be found in Appendix G-4.

Intake Flow of Scattergood Generating Station

Conclusions drawn from the 1981 316(b) demonstration at Scattergood Generating Station included the following:

1. At higher intake velocities, it appeared fewer fish were entrapped. It was believed this was attributable to rheotaxis. Increased intake velocities associated with an increase in cooling water flow is sensed more easily by fish, which orient themselves in a position to swim against the currents and away from the intake structure.

2. Depending on environmental conditions in the source water and time of day, relationships between impingement and flow conditions varied.

Comparisons of total flow between heat treatments as well as mean daily flow between heat treatments and the following were examined in the present study: total abundance, total biomass, critical species abundance, and number of species. Mean daily flow between heat treatments ranged from 63 mgd to 442 mgd, while total flow between heat treatment operations ranged 1 from 4.2 trillion gallons to 41.1 trillion gallons.

Several significant positive correlations were made with respect to mean daily flow at Scattergood Generating Station. Fish biomass (r = 0.530), chub mackerel abundance (r = 0.491), Pacific sardine abundance (r = 0.463), barred sand bass abundance (r = 0.453), total fish abundance (r = 0.422), and number of fish species impinged (r = 0.395) all correlated positively to mean daily flow (F < 0.05) (Table 2.8). These factors increase with increased mean daily flow. Of the twenty parameters compared with mean daily flow between heat treatments, there are 17 positive correlations and three negative correlations. Correlation data are in Appendix G-5.

Of the twenty parameters compared with total flow between heat treatments, there are 19 positive correlations and one negative correlation (Table 2.9). Significant positive correlations with respect to total flow include number of fish species impinged (r = 0.506), barred sand bass abundance (r = 0.481), salema abundance (r = 0.461), fish biomass (r = 0.422), yellowfin croaker abundance (r = 0.397), and kelp bass abundance (r = 0.344). These factors increase with an increase in total flow between heat treatments. Complete correlation data are in Appendix G-6.

Fishes included as critical taxa in this survey, which have been observed exhibiting rheotropic behavior with intake flows, include blacksmith, pile perch, kelp bass, and jack mackerel. This behavior may occur as just chance encounters with the intake flow while foraging and feeding around the structure, or they may utilize the flow as a feeding station itself (Helvey and Dorn 1981). It is thought that the intake may serve as a schooling

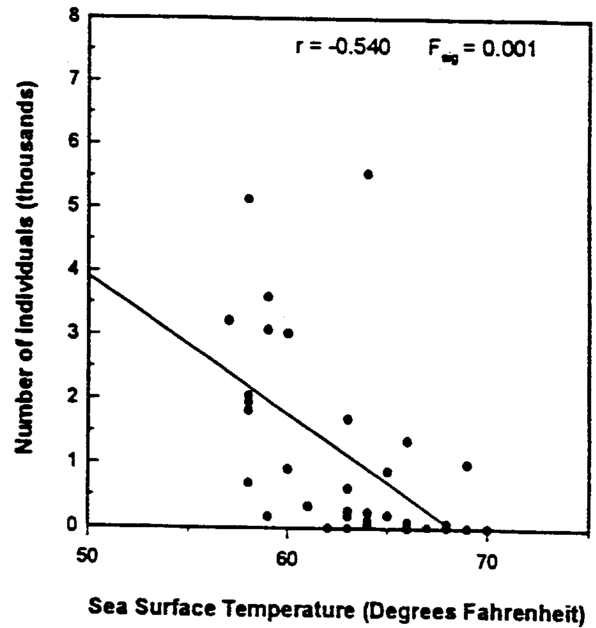

Figure 2.44. Scatter diagram of number of queenfish (*Seriphus politus*) measured during heat treatments at Scattergood Generating Station 1989-1995 and average Santa Monica Bay sea surface temperature since the last heat treatment.

Table 2.5. Correlations of mean wave height between heat treatments with 20 parameters.

Parameter	r-value	F-value
queenfish	0.447	0.042*
walleye surfperch	0.330	0.143
jack mackerel	0.109	0.656
northern anchovy	0.101	0.663
abundance	0.087	0.708
topsmelt	0.066	0.776
number of species	0.066	0.775
yellowfin croaker	0.006	0.981
white croaker	-0.016	0.945
salema	-0.057	0.808
chub mackerel	-0.058	0.804
Pacific sardine	-0.109	0.639
biomass	-0.154	0.505
California halibut	-0.165	0.476
sargo	-0.229	0.317
blacksmith	-0.306	0.178
white seabass	-0.312	0.169
jacksmelt	-0.323	0.154
barred sand bass	-0.333	0.141
kelp bass	-0.413	0.063

*indicates significance at 0.05 level.

Table 2.6. Correlations of number of days of rain between heat treatments with 20 parameters.

Parameter	r-value	F-value
walleye surfperch	0.684	0.001*
queenfish	0.408	0.067
number of species	0.401	0.071
salema	0.267	0.243
white croaker	0.207	0.368
Pacific sardine	0.075	0.748
abundance	0.035	0.881
jack mackerel	0.014	0.952
barred sand bass	-0.029	0.901
chub mackerel	-0.029	0.901
biomass	-0.032	0.890
yellowfin croaker	-0.051	0.827
blacksmith	-0.075	0.746
northern anchovy	-0.084	0.719
jacksmelt	-0.128	0.579
sargo	-0.134	0.564
kelp bass	-0.160	0.487
white seabass	-0.173	0.454
California halibut	-0.202	0.380
topsmelt	-0.219	0.341

*indicates significance at 0.05 level.

Table 2.7. Correlations of number of days between heat treatments with 20 parameters.

Parameter	r-value	F-value
number of species	0.404	0.018*
salema	0.380	0.027*
walleye surfperch	0.360	0.036*
barred sand bass	0.328	0.058
yellowfin croaker	0.277	0.113
biomass	0.226	0.198
white croaker	0.201	0.254
sargo	0.197	0.263
queenfish	0.190	0.281
kelp bass	0.184	0.297
chub mackerel	0.127	0.474
white seabass	0.115	0.517
northern anchovy	0.112	0.528
abundance	0.105	0.553
Pacific sardine	0.091	0.606
blacksmith	0.083	0.642
jacksmelt	0.041	0.817
jack mackerel	-0.013	0.940
topsmelt	-0.056	0.753
California halibut	-0.126	0.476

*indicates significance at 0.05 level.

companion, or reference point, for schooling jack mackerel (Atz 1953, Hunter and Mitchell 1967).

IMPACT ASSESSMENT

The following is an analysis of plankton loss through entrainment and adult fish loss through impingement and entrainment in the Scattergood Generating Station cooling water intake system. Plankton entrainment at Scattergood Generating Station has not been studied since the 1981 316(b) demonstration. Zooplankton, fish egg, and ichthyoplankton losses estimated in the 1981 study are used for the purposes of this study.

The 1981 316(b) study (IRC 1981) assumed median daily flow as 1.44 X 10^6 m^3/day (equivalent to 380.4 mgd or 138,846 million gallons per year). Since 1981, intake flow at Scattergood Generating Station has averaged 76% that annual volume (106,594 million gallons per year or 292 mgd). Therefore, estimates presented in this section probably represent a worst case scenario.

Source waters are considered the volume of water in Santa Monica Bay shoreward of the 90-ft depth contour.

Zooplankton

Effects of entrainment mortality on population equilibrium were examined for *Acartia* spp. adults and *Metamysidopsis elongata*. Both are considered important links of the marine food chain; thus, any impact detrimental to their relative populations as a whole would affect transfer of energy from primary producers to marine carnivores.

Conversely, little or no effect sustained by these populations would probably not affect subsequent trophic levels.

The loss of individuals from a population is a constant process through natural mortality and predation. With a population in equilibrium, these losses are replaced by reproduction which can vary with factors such as food availability, fecundity, temperature, etc. In most natural populations, a portion of the stock can be extracted without affecting the population equilibrium. In fisheries science, this extracted portion is referred to as the "maximum sustainable yield." IRC (1981a) assumed this maximum loss rate to be 5%, which was supported by the scientific literature, and the EPA who had stated that larval entrainment losses resulting in 5% reductions of standing stock of soft-shell clam was "insignificant."

The entrainment losses for zooplankton are variable depending on the size of the organism and the structure. IRC (1981a) measured mortality rates for selected species ranging from 71 to 80%. To estimate the effects of such losses on the source waters was deemed difficult, since the ocean is an open biological system and populations seemingly infinite. Based on field measurements, it was determined that waters entering the cooling water system came from a "maximum" distance of 14 m from the intake. Beyond this distance there was no measurable flow toward the intake. This body of water was described as the "source water."

As a method of calculating/expressing the potential effect of entrainment losses on source water populations, the volume of source water required to allow the entrainment mortality of selected species to represent a population loss of 5% or less was calculated. This water represents the minimum potential source water volume that would support the continuous loss and allow the population to maintain equilibrium. This source volume was then compared to the potential source water volume associated with the species local geographic range to determine appropriateness and reasonableness.

Using through-plant mortality levels 81.4% for *Acartia* spp. adults and 75.0% for *Metamysidopsis elongata*, projected source water volumes required to support a 5% mortality due to entrainment at Scattergood Generating Station and periods of maximum impact were estimated (Table 2.10). For

Table 2.8. Correlations of mean daily circulating water flow between heat treatments with 20 parameters.

Parameter	r-value	F-value
biomass	0.530	0.001*
chub mackerel	0.491	0.003*
Pacific sardine	0.463	0.005*
barred sand bass	0.453	0.006*
abundance	0.422	0.012*
number of species	0.395	0.019*
jack mackerel	0.308	0.072
jacksmelt	0.304	0.075
topsmelt	0.284	0.099
blacksmith	0.273	0.113
white seabass	0.243	0.160
kelp bass	0.228	0.188
sargo	0.217	0.211
white croaker	0.206	0.235
salema	0.188	0.279
yellowfin croaker	0.131	0.453
northern anchovy	0.063	0.721
California halibut	-0.029	0.869
walleye surfperch	-0.050	0.777
queenfish	-0.077	0.659

*indicates significance at 0.05 level.

Table 2.9. Correlations of total circulating water flow between heat treatments with 20 parameters.

Parameter	r-value	F-value
number of species	0.506	0.002*
barred sand bass	0.481	0.003*
salema	0.461	0.005*
biomass	0.422	0.012*
yellowfin croaker	0.397	0.018*
kelp bass	0.344	0.043*
sargo	0.290	0.092
chub mackerel	0.290	0.091
Pacific sardine	0.271	0.115
white croaker	0.240	0.166
abundance	0.236	0.173
blacksmith	0.223	0.199
walleye surfperch	0.189	0.277
white seabass	0.161	0.354
queenfish	0.144	0.410
jacksmelt	0.139	0.426
jack mackerel	0.091	0.602
northern anchovy	0.083	0.634
topsmelt	0.003	0.985
California halibut	-0.165	0.344

*indicates significance at 0.05 level.

Table 2.10. Projected source water volumes required to support a 5% zooplankton entrainment mortality rate at the Scattergood Generating Station and periods of maximum impact (modified from IRC 1981a).

Taxa	Period of Maximum Impact	Projected Source Water Volume (m^3) at a 5% Impact Level
Acartia spp. (adults)	4 weeks	806,000,000
Cancer spp. (zoeae)	4 weeks	806,000,000
Emerita analoga (zoeae)	6 weeks	1,210,000,000
Acanthomysis macropsis	16 weeks	1,750,000,000
Neomysis kadiakensis	16 weeks	1,720,000,000
Metamysidopsis elongata	16 weeks	1,630,000,000

copepods and mysids, period of maximum impact represents the maximum period which entrainment loss accumulates without compensation by reproduction; for invertebrate meroplankton and ichthyoplankton, it is the maximum period one generation of a given population is susceptible to entrainment loss.

IRC (1981a) concluded that the entrainment losses measured had no detectable effect on selected zooplankton and phytoplankton source water populations. This conclusion was supported by EPRI (1979) who reviewed similar studies at 75 power plants nationwide. EPRI concluded that: 1) entrainment had little impact on zooplankton and phytoplankton, and the local ecosystem; 2) entrainment effects would not be observable with a reasonable sampling program; 3) changes in intertrophic-level pathways would be negligible and system stability would not be disrupted; 4) the existing database documents that the effects of entrainment are generally small and unlikely to cause ecosystem-wide effects; 5) zooplankton and phytoplankton studies are not necessary when the volume of water used is small in relation to the source water body, such as those sighted along the ocean or Great Lakes.

Ichthyoplankton

Most critical ichthyoplankton species chosen for this survey are common in a variety of habitats throughout the Southern California Bight. Spawning occurs throughout a wide geographic area and larvae are generally widely dispersed, which is why populations of most critical taxa are widespread throughout the Southern California Bight. Defining source waters as those within Santa Monica Bay shoreward of the 90-ft depth contour should effectively encompass the distribution of critical ichthyoplankton taxa.

In assessing the effect of entrainment losses of fish eggs and larvae, IRC (1981a) provide two approaches.

The first, identical to that utilized for zooplankton and phytoplankton, relied on the comparison of source water volume capable of maintaining a population loss not greater than 5%, to the project source water volume (Santa Monica Bay). This methodology is appropriate since the eggs and larvae are part of the zooplankton community.

The second approach calculated the theoretical "equivalent adult losses." That is, the number of eggs and larvae that would have survived to adult had they not been lost due to entrainment. Under natural conditions, the survival rates for fish eggs and larvae is very low. Perhaps only one larvae in 1,000 will produce an adult fish. This methodology is commonly used for measuring the effects on adult populations.

Based on an assumed 5% loss rate, projected source water volumes necessary to support these entrainment losses are presented in Table 2.11. The period of maximum impact is considered the maximum period one generation of a given population is susceptible to entrainment loss. Compared with source water populations of these fish, and numbers removed by sportfishers, these numbers are considered relatively small. All projected source water volumes estimated represent only a small portion of estimated source waters in Santa Monica Bay. Therefore, the effect was considered minor.

Table 2.11. Projected source water volumes required to support a 5% ichthyoplankton entrainment mortality rate at the Scattergood Generating Station and periods of maximum impact (modified from IRC 1981a).

Taxa	Period of Maximum Impact	Projected Source Water Volume (m^3) at a 5% Impact Level
Fish Eggs		
Engraulis mordax	2 days	57,600,000
Sciaenid Species Complex	2 days	36,600,600
Pleuronichthys spp.	2 days	42,300,000
Fish Larvae		
Atherinid Species Complex	14 days	403,000,000
Engraulid Species Complex	28 days	791,000,000
Genyonemus lineatus	30 days	864,000,000
Seriphus politus	25 days	720,000,000
Pleuronichthys spp.	28 days	806,000,000

Equivalent adult losses for abundant ichthyoplankton taxa are shown in Table 2.12. Values varied from 9.88 X 10^3 to 9.46 X 10^4 individuals. It was concluded that these losses were exceptionally small compared with populations within Santa Monica Bay, and were similar to losses associated with routine biological monitoring.

Fish

Fish Impinged During Heat Treatments 1989-1995.

During 1978-1979 impingement sampling (IRC 1981a), annual adult fin fish loss at the Scattergood Generating Station was estimated to be 14,656 lbs. Between 1989 and 1995, 13,745 kg (30,307 lbs) of fish were impinged and quantified at 35 heat treatments (an average of 4,329 lbs per year or 866 lbs per heat treatment). It is apparent Scattergood Generating Station is impinging less (biomass) than estimated in the 1981 report (IRC 1981a).

Table 2.12. Equivalent adult fish losses associated with an estimated 5% ichthyoplankton entrainment mortality rate at the Scattergood Generating Station (modified from IRC 1981a).

Taxa	Equivalent Adult Loss
Fish Eggs	
Engraulis mordax	13,300
Sciaenid Species Complex	94,600
Fish Larvae	
Atherinid Species Complex	84,600
Engraulid Species Complex	9,880
Genyonemus lineatus	23,200
Seriphus politus	25,100
Total Equivalent Adult Loss	250,680

For each species of fish, the total number of individuals impinged was divided by 35 (number of heat treatments 1989-1995) to obtain an "average" of individuals impinged per heat treatment. A total of 35 heat treatments occurred over a 74-month period, resulting in an average of one heat treatment every 2.11 months or about six heat treatments per year. The "average" number of individuals occurring per heat treatment was multiplied by six to obtain the "average" number of individuals occurring per year.

Where possible, standing stock estimates were derived from biological monitoring efforts in Santa Monica Bay. Estimates of standing crop (biomass) were derived similarly.

It should be noted that using trawl data to determine standing stocks is probably more reliable with fish species which spend the majority of their time on the bottom (California halibut, for instance). However, with fish species which are mainly found in the water column or near the surface, the bottom trawl does not sample a representative portion of the population.

Numbers of fish impinged at Scattergood Generating Station are compared with numbers of fish reported caught in applicable Southern California catch blocks between 1989 and 1994, as defined by the California Department of Fish and Game (Figure 2.45). The intake and discharge structures for the Scattergood Generating Station are located in Catch Block 701. The remainder of the source water is located in Blocks 678,679, and 702. Blocks 680, 703, 721, and 720 all have portions located in Santa Monica Bay, but data would also include outlying areas, so they have not been utilized in the present study. Catch data from sportfishing landings as reported by the Los Angeles Times have also been used to compare with numbers of fish impinged at the Scattergood Generating Station.

***Trachurus symmetricus*.** Since jack mackerel were not present in trawls, a population estimate was not made. An average of 11,862 jack mackerel have been impinged yearly since 1989 (Table 2.13). The mean annual number of jack mackerel taken by Santa Monica Bay sportfisheries in 1959,1993 and 1994 was 2,547. This is not surprising since jack mackerel are not usually targeted by sportfisheries, but this species receives more attention when larger adults move inshore (Love 1991).

***Seriphus politus*.** Standing stock estimates of queenfish range from 9.90 X 10^7 to 4.12 X 10^8 individuals (Table 2.13). The average number of queenfish impinged per year is 6,596 individuals (Table 2.3). This represents 0.16 to 0.67% of the population estimate. Total standing crop of queenfish is estimated at 2.28 X 10^6 to 9.50 X 10^6 kg. Average annual impingement of queenfish at Scattergood Generating Station represents 0.002 to 0.007% of estimated biomass. Queenfish are generally not targeted by sportfishers, but may be taken as part of their "by-catch."

***Atherinops affinis*.** No estimates of standing stock were made since topsmelt were not present in trawls. An average of 4,119 individuals have been impinged yearly at the Scattergood Generating Station (Table 2.13).

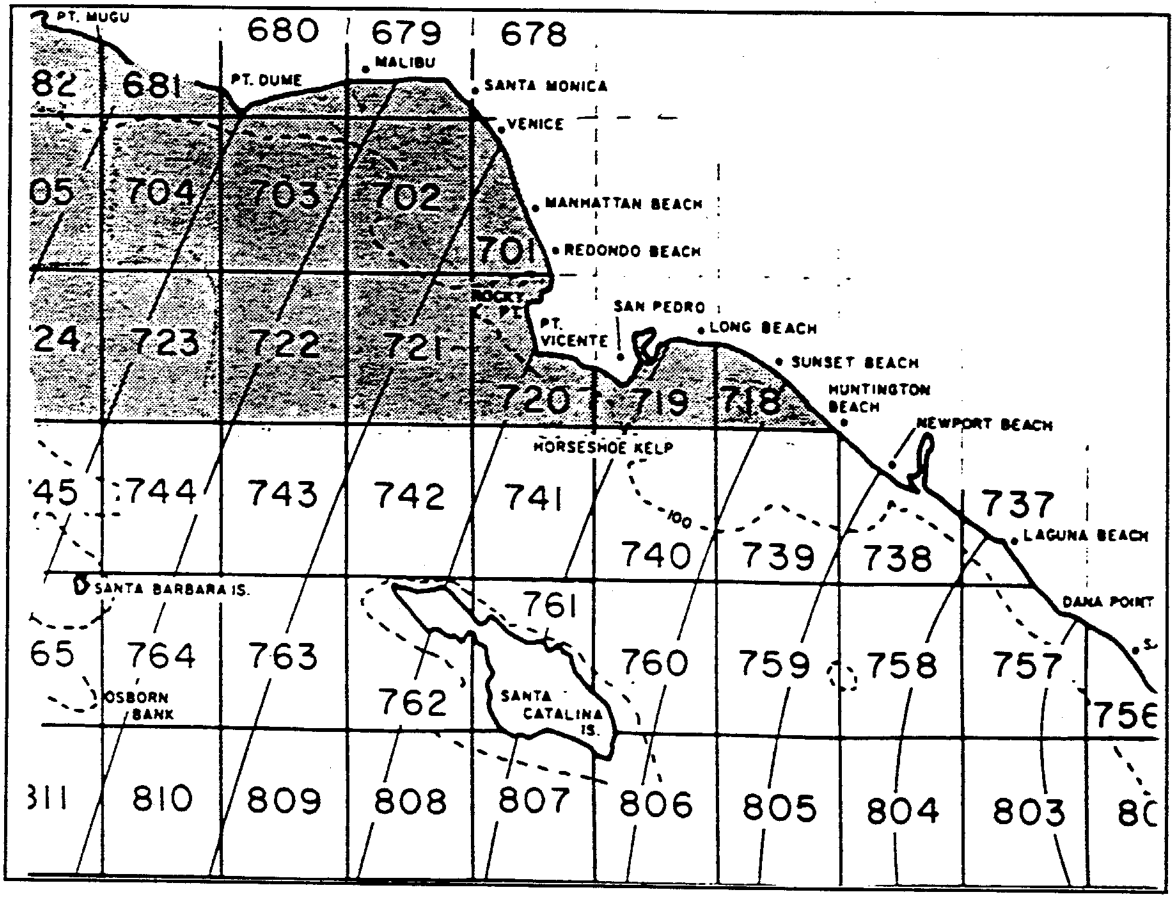

Figure 2.45. Location of California Department of Fish and Game catch blocks.

Atherinopsis californiensis. No estimates of standing stock were made since jacksmelt were not present in trawls. An average of 2,883 individuals per year have been impinged in 25 heat treatments at Scattergood Generating Station (Table 2.13).

Engraulis mordax. Estimates of standing stock range from 2.08 X 10^6 to 8.67 X 10^6 individuals in the source waters (Table 2.13). The average number of northern anchovies impinged per year is 2,495 individuals, representing 0.0003 to 0.001% of the estimated standing stock. Standing crop estimates range from 1.30 X 10^5 to 5.4 X 10^5 kg. Biomass of impinged northern anchovy represents less than 0.001% of these estimates. As northern anchovy are generally not considered bottom-dwellers, the population estimates derived from trawls are likely low.

Sardinops sagax. Pacific sardine were present in trawls only during the summer 1986 survey. Standing stock estimates range from 3.53 X 10^6 to 1.47 X 10^7 individuals (Table 2.13). Annually, the average number of Pacific sardine impinged at Scattergood Generating Station is 1,800. This represents 0.012 to 0.051% of population estimates. Standing crop estimates range from 5.66 X 10^3 to 2.35 X 10^4 kg. Biomass of impinged Pacific sardine represents 0.012 to 0.051% of these estimates. Since Pacific sardine are pelagic schoolers, population estimates derived from trawls are probably low.

Table 2.13. Scattergood Generating Station impingement averages, population estimates based on 12%, 30%, and 50% catch efficiencies, percent of estimated standing stock lost to impingement, numbers of fish reported caught in catch blocks, comparison of fish impinged at Scattergood Generating Station and fish reported caught in catch blocks, and comparison of annual number of fish impinged at Scattergood Generating Station, and average number of fish reported caught in Santa Monica Bay landings annually.

	Trachurus symmetricus	*Seriphus politus*	*Atherinops affinis*	*Atherinopsis californiensis*	*Engraulis mordax*	*Sardinops sagax*	*Genyonenus lineatus*	*Xenistius californiensis*	*Umbrina roncador*	*Hyperprosopon argenteum*	*Anisotremus davidsonii*	*Scomber japonicus*	*Paralabrax nebulifer*	*Chromis punctipinnis*	*Paralabrax clathratus*	*Atractoscion nobilis*	*Paralichthys californicus*	*Sebastes spp.*
Total impinged by SGS 1989-1995	69195	38479	24029	16820	14561	10500	9063	7770	5471	3320	3179	3168	2296	1714	1322	149	37	189
Average impinged per HT	1977	1099	687	481	416	300	259	222	156	95	91	91	66	49	38	4	1	5
Average impinged annually	11862	6596	4119	2883	2496	1800	1554	1332	938	569	545	543	394	294	227	26	6	32
Estimated population x 100,000																		
based on 12% net efficiency		4130			8670	147	3420		21.8	22.4			73.6	54.2	29.4	2.36	506	
based on 30% net efficiency		1650			3470	58.8	1370		8.71	8.94			29.4	21.7	11.8	0.942	202	
based on 50% net efficiency		991			2080	35.3	821		5.23	5.37			17.7	13	7.07	0.566	121	
% ann. impinge. est. population																		
based on 12% net efficiency		0.0016			0.0003	0.0122	0.0005		0.043	0.0254			0.0053	0.0054	0.0077	0.0108	1.25E-05	
based on 30% net efficiency		0.004			0.0007	0.0306	0.0011		0.1077	0.0636			0.0134	0.0136	0.0193	0.0271	3.14E-05	
based on 50% net efficiency		0.0067			0.0012	0.0509	0.0019		0.1793	0.1059			0.0223	0.0226	0.0321	0.0452	5.22E-05	
1989 to 1994 Block 701 catch		0					1294					155038	184412		56104		5220	
1989 to 1994 SGS % to Block 701							498.6					1.8	1		2.1		0.7	
1989 to 1994 all SMB blocks		0					1839					203222	269345		71433		8547	
1989 to1994 SGS % to all blocks							350.8					1.4	0.7		1.6		0.4	
SMB landings annual mean	2547.3						147.6					131621	65333		54920		5382	404052
% SGS annual mean to SMB	465.7						1052.6					0.4	0.6		0.4		0.1	0.008

Population estimates from 1986, 1988 SGS NPDES Trawls

All SMB catch blocks include: 678 679 701 702

SMB landings include: Paradise Cove, Paradise Cove Barge, Malibu, Malibu Barge, Sana Monica, Santa Monica Barge, Marina del Rey, Hermosa Beach, Hermosa Pier, Redondo, Redondo Barge

***Genyonemus lineatus*.** Standing stock estimates vary from 8.21 X 10^7 to 3.42 X 10^8 individuals (Table 2.13). Scattergood Generating Station has impinged 1,554 white croaker per year on average. This corresponds to 0.00046 to 0.0019% of the estimated standing stock. Standing crop estimates range from 2.33 X 10^6 to 9.71 X 10^6 kg. Biomass of impinged white croaker represents less than 0.001 to 0.002% of estimated biomass in the source waters. Comparatively, 1,294 white croaker have been caught by sportfishers in Catch Block 701. The mean number of white croaker reported caught by Santa Monica Bay sportfishing landings during 1959, 1967, 1983, and 1991 through 1994 was 148 individuals. This is not surprising since white croaker is not usually targeted by sportfishermen.

***Xenistius californiensis*.** Estimates of standing stock were not made due to low abundance in trawl catches. Since 1989, Scattergood Generating Station has impinged an average of 1,332 salema per year (Table 2.13).

***Umbrina roncador*.** Yellowfin croaker were present in two of the four trawl surveys. Standing stock estimates range from 5.23 X 10^5 to 2.18 X 10^6 individuals (Table 2.13). An average of 938 yellowfin croaker are impinged by Scattergood Generating Station each year; this is equal to 0.04 to 0.18% of the estimated standing stock in the source waters. Standing crop estimates range from 3.82 X 10^4 to 1.59 X 10^5 kg. Biomass of yellowfin croaker impinged at Scattergood Generating Station represents 0.043 to 0.179% of estimated biomass.

***Hyperprosopon argenteum*.** An average of 569 walleye surfperch are impinged annually at the Scattergood Generating Station. Population estimates range from 5.37 X 10^5 to 2.24 X 10^6 walleye surfperch in the source waters (Table 2.13). Annual impingement at Scattergood Generating Station represents 0.03 to 0.11% of standing stock estimates. Standing crop estimates range from 4.81 X 10^4 to 2.00 X 10^5 kg. Biomass of walleye surfperch impinged annually represents 0.025 to 0.106% of estimated biomass.

***Anisotremus davidsonii*.** No population estimates of sargo were made. On average, Scattergood Generating Station impinges 545 sargo per year (Table 2.13).

***Scomber japonicus*.** The mean number of chub mackerel caught by Santa Monica Bay sportfishing landings during the years 1959, 1967, 1975, 1983, and 1991-1994 was 131,621 (Table 2.13). The mean number impinged at the Scattergood Generating Station represents 0.41% of that figure. The total number of chub mackerel caught in Catch Block 701 between 1989 and 1994 was 155,038, while the total caught in Catch Blocks 678, 679, 701, and 702 was 203,222 individuals. The number impinged by the Generating Station during the same time period represents 1.81 and 1.38%, respectively, of the number of chub mackerel reported in the Catch Blocks.

No population estimates of chub mackerel were made.

***Paralabrax nebulifer*.** Population estimates from trawl-caught barred sand bass range from 1.77 X 10^6 to 7.36 X 10^6 individuals (Table 2.13). On average, Scattergood Generating Station impinges 394 barred sand bass per year; these fish represent 0.005 to 0.02% of the estimated population. Standing crop estimates range from 3.35 X 10^5 to 1.40 X 10^6 kg in the source waters. Biomass of barred sand bass impinged annually represents 0.005 to 0.022% of estimated biomass. The total number of barred sand bass caught in Catch Block 701 between November 1989 and 1995 was 184,412 individuals. The number of barred sand bass impinged by Scattergood Generating Station during the same time period was 1,886, or, 1.02% of the reported catch in Block 701. When including Blocks 678, 679, and 702 (269,345 individuals caught), the number impinged at the Scattergood Generating Station equals 0.7% of the total catch in those blocks. At Santa Monica Bay landings, during 1959, 1967, 1975, 1983, and 1991-1994, the mean number of barred sand bass caught annually was 65,333 individuals. The annual average of impinged barred sand bass represents 0.6% of that figure.

***Chromis punctipinnis*.** Blacksmith occurred in only one of the four trawl surveys. Estimated standing stock range from 1.30 X 10^6 to 5.42 X 10^6 blacksmith in the source waters (Table 2.13). Since 1989, Scattergood has, on average, impinged 294 blacksmith per year (0.01 to 0.02% of the standing stock). Likewise, biomass of impinged blacksmith represents 0.005 to 0.023% of standing crop estimates.

***Paralabrax clathratus*.** Kelp bass occurred in only one of the four trawl surveys. Population estimates vary from 7.07 X 10^5 to 2.94 X 10^6 individuals in the source waters (Table 2.13). The average number of kelp bass impinged by Scattergood Generating Station (227 individuals annually) represents 0.0076 to 0.032% of the estimated population. Biomass of kelp bass impinged at Scattergood Generating Station represents 0.684 to 2.85% of estimated standing crop. 56,104 kelp bass were caught in Catch Block 701 between November 1989 and December 1994. The number impinged at Scattergood Generating Station during the same time period (1,166 individuals) represents 2.08% of the local catch. 71,433 kelp bass were caught in Catch Blocks 678, 679, 701 and 702 between 1989 and 1994. The kelp bass impinged at the Generating Station represent 1.63% of the catch in those blocks. The mean annual catch by Santa Monica Bay landings during the years 1959, 1967, 1975, 1983, and 1991 through 1994 was 54,920 kelp bass. The average annual impingement of kelp bass at the Scattergood Generating Station equals 0.41% of that annual mean.

***Atractoscion nobilis*.** White seabass occurred in the Summer 1988 trawl survey. Population estimates derived from its abundance in trawls range from 5.66 X 10^4 to 2.36 X 10^5 individuals in the source waters (Table 2.13). The average number of fish impinged at Scattergood Generating Station yearly (26 white seabass) represents 0.01 to 0.05% of the standing stock estimate. Biomass of white seabass in the source water is estimated between 2.69 X 10^4 to 1.12 X 10^5 kg. Biomass of white seabass impinged annually represents 0.005 to 0.022% of estimated standing crop.

***Paralichthys californicus*.** California halibut were present in all trawl surveys. Since halibut are true bottom-dwellers, standing stock estimates are probably more reliable than for other species. Standing stock estimates from Scattergood Generating Station trawl surveys range from 1.21 X 10^7 to 5.06 X 10^7 individuals (Table 2.13). Population estimates from Hyperion Treatment Plant trawl surveys range from 7.20 X 10^6 to 3.0 X 10^7 individuals in the source waters. A total of 37 California halibut have been impinged at Scattergood Generating Station since 1989, giving an annual average of six California halibut impinged. This represents 0.000013 to 0.000052% of the standing stock estimates from Scattergood NPDES surveys, and 0.000021 to 0.000088% of population estimates from Hyperion Treatment Plant trawl surveys. Using biomass from Scattergood Generating Station NPDES trawl surveys, biomass of impinged California halibut represent less than 0.001% of estimated standing crop. During 1959, 1967, 1975, 1983, and 1991 through 1994, the annual mean number of California halibut caught by Santa Monica Bay landings was 5,382 fish. Compared with this figure, the average annual impingement at the Scattergood Generating Station equals 0.118% of the catch. 5,220 California halibut were caught in Catch Block 701 between November 1989 and December 1995. The number impinged by the Generating Station is equal to 0.67% of the catch in Block 701. Including Catch Blocks 678, 679, and 702, the number impinged annually by Scattergood Generating Station represents approximately 0.41% of the catch in Santa Monica Bay.

Sebastes spp. Catch Block data for rockfish was made available from the California Department of Fish and Game. Since 1989, Scattergood Generating Station has impinged 189 individuals of four species of rockfish (an average of 32 per year) (Table 2.13). During 1959, 1967, 1975, 1983, and 1991 through 1994, Santa Monica Bay landings caught and average of 404,052 rockfish annually. The number of rockfish impinged annually by the Scattergood Generating Station represents 0.008% of the Santa Monica Bay catch (Table 2.13).

In summary, the numbers of fish impinged by the Scattergood Generating Station generally represent less than 2% of fish taken by sportfishermen locally (chub mackerel, barred sand bass, kelp bass, and California halibut). White croaker and queenfish are not usually sought by sportfishing vessels, and it is believed that fish included in Catch Block data are probably "by-catch." Population estimates are conservative for all species of fish, except possibly California halibut, the critical species which probably spends the most time on the bottom. Still, population losses due to impingement were below 0.2% for species of fish where available data was sufficient to estimate a standing stock. Losses due to impingement at the Scattergood Generating Station are not significant, and it appears the stability of nearshore fish populations is being preserved.

BEST TECHNOLOGY AVAILABLE

Analysis of plankton data collected during 1978 and 1979 and fish data collected between 1986 and 1995 shows Scattergood Generating Station is minimizing adverse environmental effects through the use of best technology available. Low impacts from entrapment and impingement demonstrated insignificant losses to marine life in the surrounding waters.

The California State Water Resources Control Board's 316(b) Guidelines (1977) classified cooling water intake systems as low, medium, or high potential impact. Criteria used in classifying impacts included the following: 1) Fish mortality of over 30,000 lbs per year; 2) intake situated in an area of very high value aquatic habitat; 3) intake volume over 1,500 cfs; 4) entrainment period long due to conduits; 5) local presence of rare, endangered, or threatened aquatic species; and 6) intake volume relatively low - plant less than 100 MW capacity. Prior to the original 316(b) survey, Scattergood was tentatively classified by the state as a high impact power plant based on Criteria 1) high fish mortality and on Criteria 4) entrainment period long due to long conduits.

Criteria number one was not exceeded during the present survey; since 1989, total heat treatment biomass has been 30,305 lbs (Scattergood Generating Station averages 866 lbs of fish per heat treatment, equivalent to approximately 5,196 lbs per year). Criteria number two and number five are not applicable to Scattergood Generating Station. The nearshore Santa Monica Bay area is inhabited by species common to Southern California coastal waters. The location of the Scattergood Generating Station intake structure does not affect rare, endangered, or threatened aquatic species.

Criteria number four (entrainment period long due to conduit lengths) could apply to Scattergood Generating Station. Plankton losses in the conduit system, have been shown to result mainly from predation and grazing. The demonstrated low impingement and entrainment impacts indicates long conduits may not be indicative of effects from Scattergood Generating Station. Criteria number six does not apply to Scattergood Generating Station.

For the above reasons, no alternative intake technologies were addressed. Cooling water flow since the original 316(b) survey has declined substantially, most likely leading to lower plant-related entrainment mortalities. Losses of fish at Scattergood Generating Station are likely minimized by the intake technology currently used.

A review of data from 1981 to 1995 has shown that Scattergood Generating Station is minimizing adverse environmental effects, and that the existing cooling water intake system, location, design, construction and capacity reflects the best technology available for the Scattergood Generating Station.

CHAPTER 3
HAYNES GENERATING STATION

HAYNES GENERATING STATION

CHARACTER OF THE STUDY AREA

Haynes Generating Station is located on the southern California coast in the city of Long Beach. Cooling water is withdrawn from Alamitos Bay through an intake structure located in the bulkhead of the Long Beach Marina. The Alamitos Generating Station (operated by the Southern California Edison Company) is located on the opposite side of the San Gabriel River from Haynes Generating Station. Both stations use the channel to return thermal effluent from once-through seawater cooling systems to San Pedro Bay.

The San Gabriel River is a major flood control channel which is maintained by the Los Angeles County Flood Control District. The Army Corps of Engineers completed the concrete lining of the channel in May 1964 to a designed maximum flow of approximately 13,000 million gallons per day (mgd). Coyote Creek is an important but intermittent feeder to the San Gabriel River, approximately 6.4 km upstream from the river mouth. Storm flow from Coyote Creek can constitute more than one-half of the total flow of the San Gabriel River (SCCWRP 1988). Most of the dry weather flow in the lower river is from advanced wastewater effluents (SCCWRP 1988).

The San Gabriel River empties into the eastern end of San Pedro Bay, between Alamitos Bay to the west and Anaheim Bay to the east. The seafloor in the area is a mixture of silt and fine sands, and slopes gently outward from the river mouth. Tidal influence extends upriver about 5 km from the river mouth (about 2 km upstream from the Haynes Generating Station).

Climate

Air Temperature

The climate of southern California is Mediterranean, characterized by warm, dry summers and mild, wet winters. Although less than half of the days of the year are cloudy, insolation (i.e., sunshine) is greatest from March to September. The sun heats the air, land, and water; in turn, the land and water heat the air. The average daily (24 hr) air temperature in the study area ranges from 45 to 72°F annually (SCCWRP 1973), being coldest in January and warmest in July.

A temperature inversion often develops on the Los Angeles Coastal Plain during the summer. Cool coastal air is trapped beneath warm air at higher altitudes, resulting in hazy or smoggy air. Cool air over upwelling regions of the ocean often results in fog. During late spring and early summer, fog may deepen to several thousand yards, causing drizzles throughout the Coastal Plain (Miller and Hyslop 1983).

Rainfall

The average annual rainfall on the Coastal Plain is 12 to 13 in., about 90% of which occurs between November and April (SCCWRP 1973, Kimura 1974, Miller and Hyslop 1983). In winter, cold-front storms typically come from the northwest; in summer, tropical storms called "chubascos" occasionally come from the southeast. Most storms originate over the ocean as low pressure cells, but thunderstorms occasionally result from hot air rising over land (Kimura 1974, Miller and Hyslop 1983).

Wind

Prevailing winds along the coast are from the west-northwest and wind speed is generally low throughout the year. In summer, sea breezes typically blow onshore in the morning as air over the land heats up, rises, and pulls cool air from the ocean (Miller and Hyslop 1983). At night, offshore land breezes often develop as air over the land is pulled seaward, while air over the warmer ocean rises.

During winter (but occasionally at other times), hot, dry Santa Ana winds blow to the west off the deserts east of the Los Angeles Basin. These gusty winds result from high pressure cells over the desert and enter the coastal zone through mountain passes.

El Niño Events

Every so often, with a quasiperiodicity of three to five years (Graham and White 1988), the oceanic environment of southern California changes dramatically as an El Niño Southern Oscillation event takes place. During an El Niño, the normal water mass off the California coast is replaced by water which is warmer, more saline, and lower in nutrients than usual. These conditions extend through the water column and may persist for months or years.

El Niños result from large-scale changes in the climate and oceanography of the Pacific Ocean as a whole. Normally, tradewinds north of the Equator, which blow to the west, force water to accumulate in the western Pacific. When tradewinds weaken, seawater flows easterly (as a long-period wave). When this wave encounters the Americas, it moves both north and south along the coast. Because currents in the North Pacific also decrease in strength, the south-flowing California Current is weakened and the warm-water mass from equatorial latitudes penetrates into the Southern California Bight. The most recent large El Niño event was in 1982-1983, with the previous large El Niño in 1957-1959. Events of lesser magnitude occurred in 1986-1987 and in 1991-1992 (Radovich 1961, Graham and White 1988, Kerr 1992, Tegner et al. 1995).

During an El Niño, marine organisms with more southern distributions occur more frequently in the Bight, whereas cold water species become less abundant: pelagic red crabs, which are normally found off southern Baja California, were abundant offshore southern California in 1982 and 1983. During an El Niño, the sport and commercial fisheries (and success) for pelagic species such as yellowtail, bluefin, yellowfin, bigeye and skipjack tuna, bonito, and dorado may increase dramatically. However, albacore, which prefer cooler water, may shift northward along with Pacific mackerel, which then impact the northern fisheries by preying on newly-arriving young salmon.

El Niño periods are also frequently characterized by stronger-than-normal winter storms accompanied by large waves which damage coastal structures, erode beaches, and churn up the nearshore environment. Sediment carried by terrestrial runoff and suspended by wave activity can persist along the coast, reducing visibility and algal and phytoplankton growth. Reduced nutrient levels accompanying an El Niño can result in a decline in kelp beds (Tegner et al. 1995, Dailey et al. 1993), decreasing habitat available to fish communities dependant on the kelp.

Oceanography

Currents

The waters of Alamitos Bay are isolated from open coast circulation; water exchange depends on tidal flow through the harbor entrance. The removal of large volumes of water for plant cooling purposes thus increases the influx of ocean water into Alamitos Bay. Currents and wave surge in San Pedro Bay are reduced and thus do not enhance dispersion of the discharged thermal effluent. However, the net direction of flow at the mouth of the San Gabriel River is downcoast where incoming waves and longshore currents are not inhibited by breakwaters.

Tides

Tides along the California coast are mixed semi-diurnal, with two unequal highs and two unequal lows during each 25-hr period. In the eastern North Pacific Ocean, the tide wave rotates in a counterclockwise direction. As a result, flood tide currents tend to flow onshore and upcoast and ebb tide currents flow offshore and downcoast.

Upwelling

During prolonged northwesterly winds in winter and spring, nearshore surface water is transported offshore along coasts with a northwest-southeast orientation (Dailey et al. 1993). Wind-induced friction causes the nearshore surface waters to begin moving offshore. Once moving, the Coriolis effect deflects water further offshore (Garrison 1993). Subsequently, nearshore waters are replaced by deep, oxygen-poor and nutrient-rich waters. This process is important because the nutrient-rich waters stimulate plankton productivity, the primary component of the marine food web. Frequently, patches of cold water in response to upwelling have occurred in Santa Monica Bay and over the San Pedro shelf, but generally occur less frequently and less intensely than in other coastal areas north of Point Conception (Dailey et al. 1993).

Characteristics of Seawater

Temperature

Temperature variations of coastal waters are significantly greater than those of the open ocean because of the relative shallowness of the water, influence from land runoff, localized upwelling, and turbulence generated by current and wave action. Factors contributing to the rapid daytime warming of the sea surface include weak winds, clear skies, and warm air temperature. Conversely, overcast skies, moderate air temperature, and vertical mixing of surface waters by winds and waves limit daily warming. Natural surface water temperatures in San Pedro Bay range from 55 to 78°F annually (EQA/MBC 1973). During summer months, a thermocline (strong temperature gradient with depth) may develop as a result of warming of surface waters from insolation.

Salinity

Salinity is relatively constant in the open ocean. However, in coastal environments it fluctuates as a result of the introduction of freshwater runoff, direct rainfall, and evaporation (EQA/MBC 1973). Salinities in the nearshore portions of San Pedro Bay show marked seasonal variation, ranging from 25.0 to 33.6 ppt through the year (EQA/MBC 1973).

Density and Stratification

Seawater density varies inversely with temperature and directly with salinity at a given pressure. Water temperature is the major factor influencing density stratification in southern California since salinity is relatively uniform. As a result, density gradients are most pronounced when spring and summer thermoclines are present.

Transparency to Light

The depth to which light will penetrate the ocean is dependant on numerous factors, including the absorption of light by water, the wavelength of light, transparency of the water, reflection from the water surface, suspended particles in the water column, latitude, and season of year. Water transparency (as measured by a standard Secchi disk) generally ranges from 6 to 15 m in southern California, with the lowest values occurring close to shore. A band of low transparency water is characteristic within about 1.6 km of the shore.

Light penetration is especially important to photosynthesis. Most photosynthesis occurs in the mixed layer, from the surface to water depths of about 11 m (MBC 1993b). This area is referred to as the photic zone. As light levels decrease photosynthesis decreases. The lower boundary of the photic zone is referred to as the compensation depth; no photosynthesis occurs here. Sunlight intersects the sea surface at a steeper angle in summer than in winter; thus, light penetrates more deeply in summer and the photic zone is deeper. Transparencies are generally lower during spring than during fall, probably due to an increase in freshwater runoff from land (SCCWRP 1973). Annual mean transparency in nearby Long Beach Harbor between 1971 and 1990 ranged from 1.8 to 3.7 m (MBC 1992b).

Hydrogen Ion Content (pH)

The pH of seawater is maintained by the buffering effect of the salts of carbonic acid and the salts of other weak acids and strong bases. Normal pH values in San Pedro Bay range from 7.7 to 8.3 (EQA/MBC 1973) and in Long Beach Harbor from 8.0 to 8.6 (MBC 1992a).

Dissolved Oxygen

Dissolved oxygen (DO) is utilized by aquatic animals in their metabolic processes and is replenished in the ocean by gaseous exchange with the atmosphere and as a by-product of photosynthesis. Concentrations in the study area range from approximately 5 to 14 mg/l (EQA/MBC 1973). High values usually result from increased photosynthetic activity and low values from decomposition of organic material or mixing of surface waters with oxygen depleted subsurface waters.

GENERATING STATION DESCRIPTION

Location

Haynes Generating Station is located on the Southern California coast in the city of Long Beach (Figure 3.1). Seawater utilized in the once-through cooling water system is withdrawn through an intake structure located in the bulkhead of the Long Beach Marina in Alamitos Bay. The seawater is conveyed approximately 2.4 km to the generating station through a combination of closed conduits and an open channel. After passing through the station, the cooling water is discharged into the tidal portion of the San Gabriel River which flows to the Pacific Ocean.

Figure 3.1. Location of Haynes Generating Station.

The Department has two other generating stations located along the Southern California coast that utilize seawater for similar purposes. In addition, Southern California Edison Company's Alamitos Generating Station has its cooling water intake structures located approximately 5 km from the Haynes intake.

Station Description

Haynes Generating Station consists of six steam electric generating units. The six units were sequentially brought on-line, beginning with Unit 1 in 1962, and ending with Unit 6 in 1967. Units 1-4 have a rated capacity of 230 Mw each, and Units 5 and 6 each have a rated capacity of 343 Mw. Steam is supplied to each turbo-generating unit from a separate boiler capable of being fired by either fuel oil or natural gas. The total net capacity of the generating station is 1,451 Mw when fired by gas and 1,583 Mw when fired by oil.

Cooling Water Intake System

The cooling water intake structure is located in Long Beach Marina in Alamitos Bay (Figure 3.2). The intake consists of seven separate but adjoining 15.2-m wide by 2.3-m high structures. The intake openings are located at a depth of 0.6 to 2.9 m MLLW. The depth of the marina bottom is 3 m below MLLW. The maximum design approach velocity at the intake is 18 cm/sec. Vertical bar racks, consisting of 3/8-in. by 3-in. bars spaced 6 in. on center, prevent large debris from entering the system.

Seawater is conveyed from the intake structure under the San Gabriel River through seven 8-ft diameter closed conduits approximately 1,100 ft long (Figures 3.3 and 3.4). These conduits discharge into an open, 2.4 km long channel (designed and maintained by the Department). Design velocity through the conduit is 1.6 m per second, while design velocity in the channel is 0.3 m per second. The seawater is withdrawn from the intake channel through a separate screen and pump chamber for each unit. Stationary 3/8-in. mesh screens prevent small debris, fish, and invertebrates from entering Units 1 and 2; Units 3-6 use conventional screens of the same mesh size. Design approach velocity at the screens for Units 1 and 2 is 0.15 m per second, while design approach velocity for Units 3-6 is 2 feet per second (fps). The screens are raised or rotated once each eight-hour shift for debris removal. High pressure sprays remove debris, fish, and invertebrates which are conveyed to trash baskets for disposal.

Each unit has two circulating water pumps, one for each condenser half. The pumps for Units 1-4 are vertical single-stage, manufactured by Peerless, and operate at a design flow of 48,000 gallons per minute (gpm) at 514 revolutions per minute (rpm) at a head of 18 ft. Pumps for Units 5 and 6 are vertical single-stage, manufactured by Byron-Jackson, and operate at a design flow of 80,000 gpm at 400 rpm at a head of 23 ft. Combined maximum cooling water flow for all six units is approximately 1,014 million gallons per day (mgd). Flows are pumped from the screen and pump chambers to the main steam condensers and auxiliary heat exchange systems. Design temperature differential (ΔT) across the condensers for Units 1-4 is 19°F. The ΔT for Units 5 and 6 is 15°F. After passing through their respective condensers, flows are combined in a single underground discharge conduit for each unit. Each pair of units has a discharge structure located in the dike of the San Gabriel River (Figure 3.5).

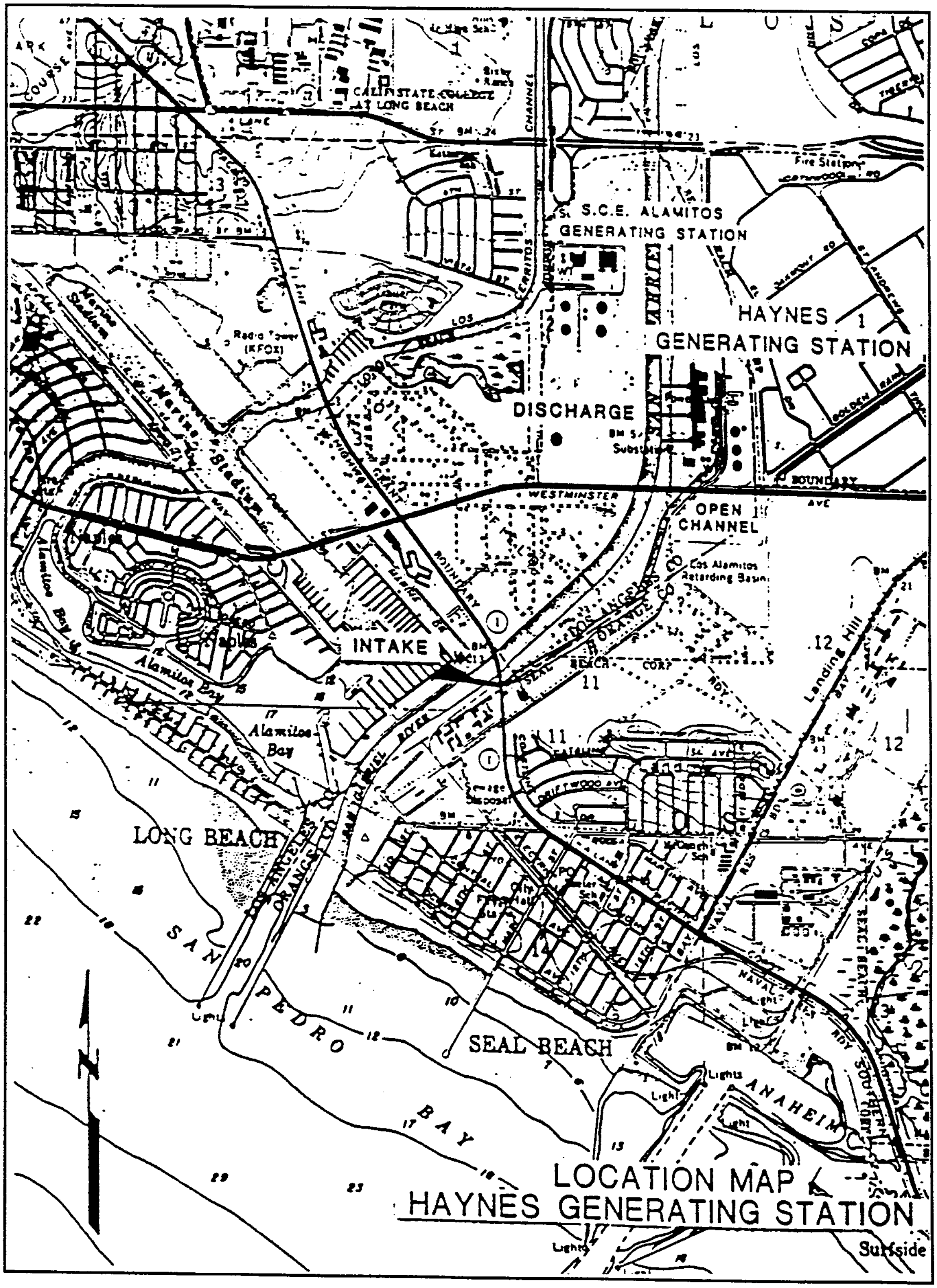

Figure 3.2. Haynes Generating Station intake and discharge lines (IRC 1981b).

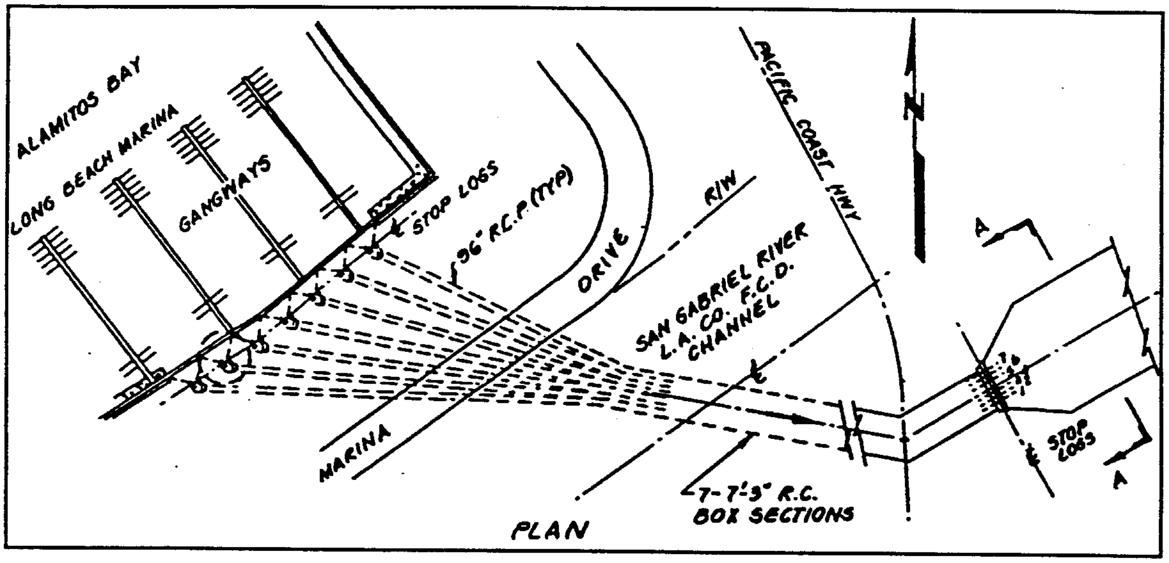

Figure 3.3. Haynes Generating Station circulating water intake conduits (IRC 1981b).

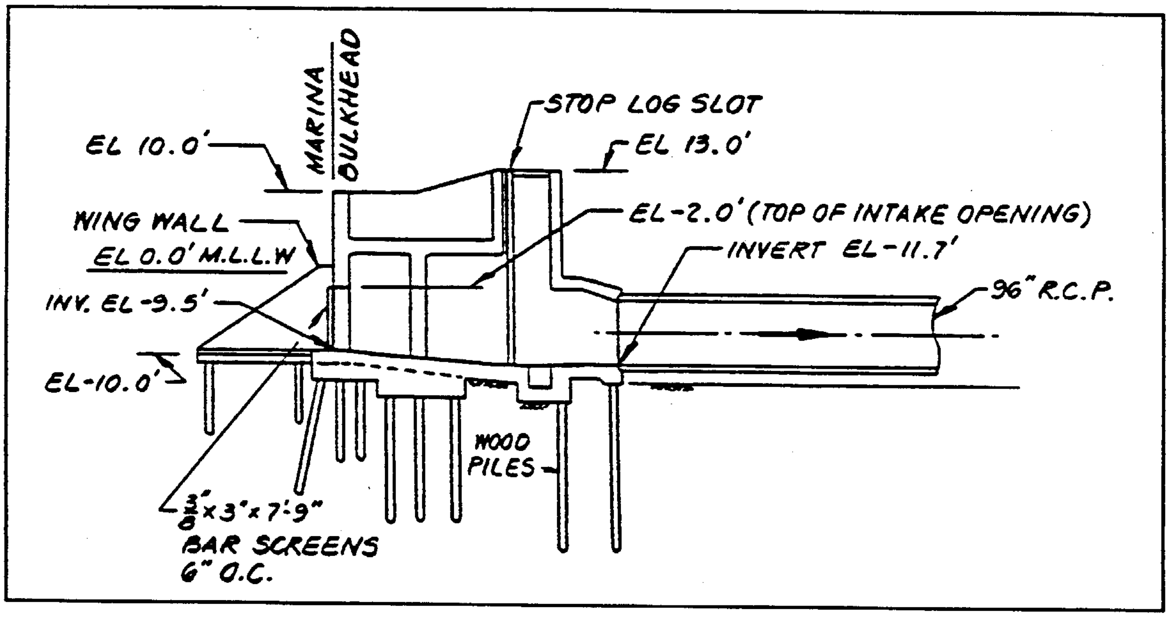

Figure 3.4. Haynes Generating Station circulating water intake structure (IRC 1981b).

Cooling Water Intake System Operations

The cooling water system is heat-treated approximately once every eight weeks to control the growth of marine fouling organisms. During this operation, a circulating water pump is shut down and the stop log gate at the discharge structure is partially lowered to obstruct the discharge flow (Figure 3.4). A portion of the flow that has passed through one condenser half flows through the other condenser half in the reverse of its normal direction, and then through the intake line to the screen and pump chamber. The flow is partially restricted from entering the intake channel by the placement of special screens. The above procedure is maintained for approximately 1.5 hrs at a temperature of approximately 115°F.

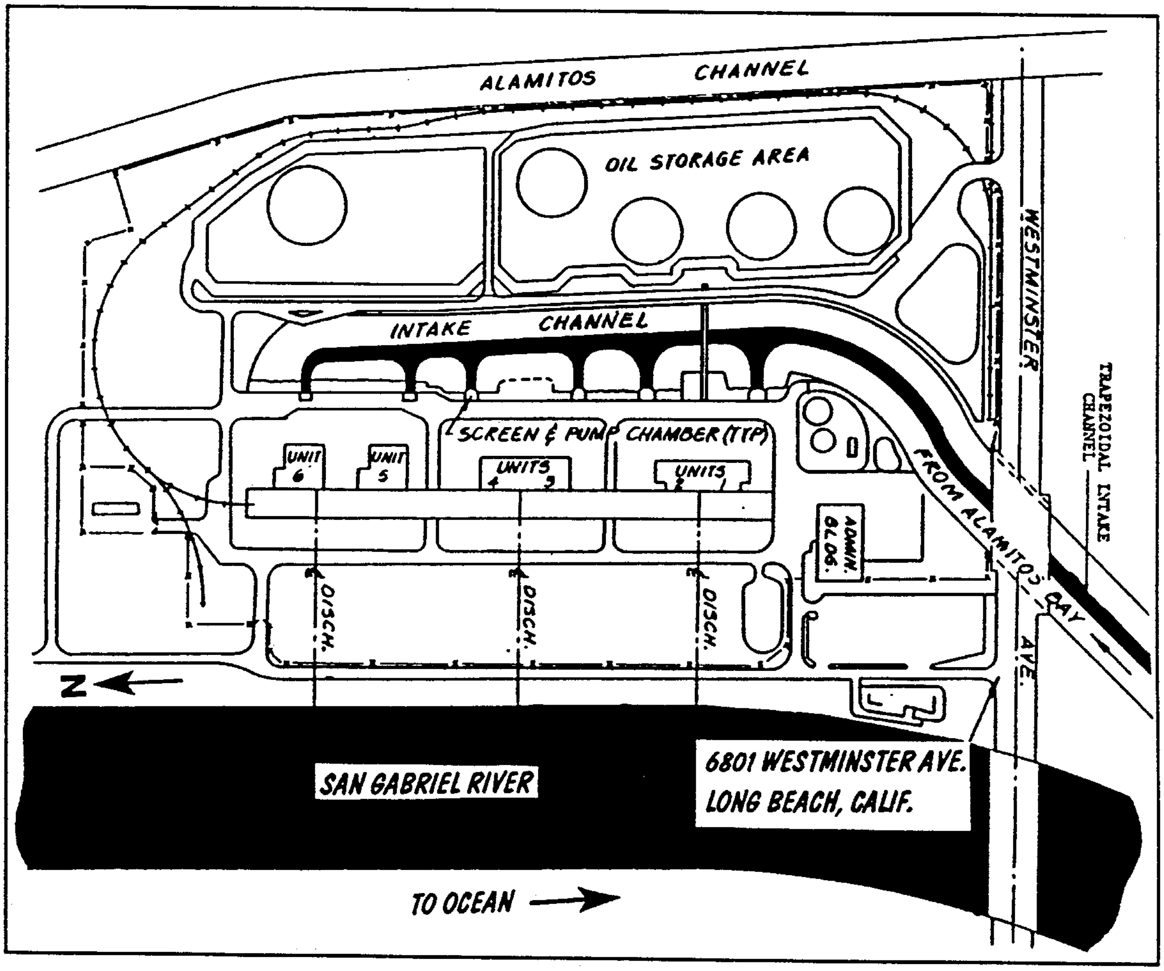

Figure 3.5. Haynes Generating Station site plan (IRC 1981b).

Condenser biofouling is controlled by the use of Amertap. This consists of spongy rubber balls which are sent through the condenser tubes to act as scrubbing devices. The balls are collected after each pass through the system and recycled.

When Amertap is inoperable, marine growth is controlled by the use of chlorine treatments. Chlorine is injected into the main cooling water stream ahead of the condensers. Injection is made to each condenser half for approximately 20 minutes each eight-hour working shift at concentrations in compliance with existing National Pollutant Discharge Elimination System (NPDES) permit limitations (CRWQB 1995b), since the chlorinated water is subsequently discharged. Other in-plant streams, such as chemical metal cleaning wastes, low volume wastes (non-chemical metal cleaning wastes, water softener regeneration wastes, demineralizer regeneration wastes, boiler and evaporator blowdowns, condensate polisher regeneration wastes, secondary treated sanitary wastes, laboratory drains and floor drainage including storm runoff), combine with the cooling water and are discharged.

Study Period Operating Characteristics

Operating characteristics for Haynes Generating Station between 1981 and 1995 can be best described by analysis of the generating capacity factors and the cooling water flow data. The capacity factor is a comparative measure of the actual plant generation to the plant generation capability. However, yearly or monthly capacity factors are a very general measure of operating characteristics. Daily and hourly generation fluctuations are not discernable from these values. Generating fluctuations can indicate cooling water temperature differentials with a corresponding effect on entrained organisms.

Cooling water flow is a better indicator of the station's operations and its effect on entrained organisms. A direct relationship exists between cooling water flow and the number of organisms entrained.

Operating characteristics for the period October 1978 through September 1979 were described in detail in Haynes Generating Station's 1981 316(b) Demonstration Study (IRC 1981b). During that period, the capacity factor for the plant averaged 46%, compared with a 60% average during the 10 years prior to the study period. The winter peak load was December 1978 (60% capacity) and the summer peak load was July 1979 (47.5% capacity). Between 1981 and 1995, the plant capacity factor averaged 22.6% (Figure 3.6; Castro 1996, pers. comm.). Lowest monthly generating capacity was in September 1988 (3.03% capacity) and highest was in June 1981 (52.16%).

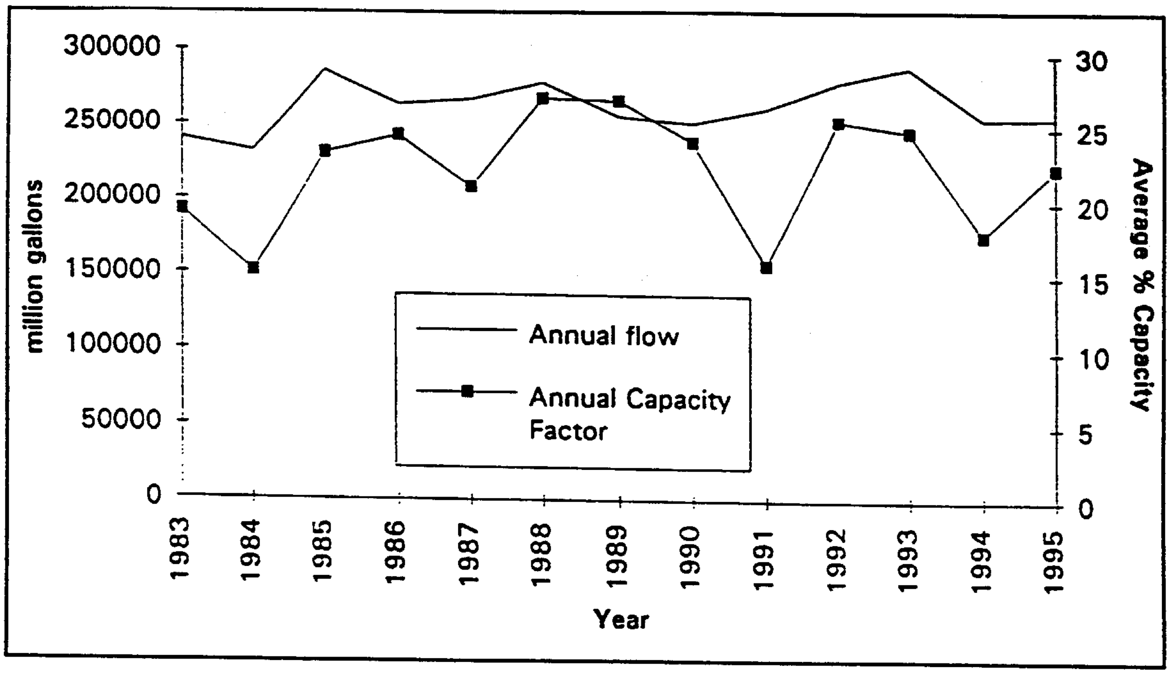

Figure 3.6. Comparison of Haynes Generating Station annual circulating water flow (million gallons) and average generating capacity from 1983 to 1995.

Total flow during for the period October 1978 through September 1979 was 270,253 million gallons (73% of design flow). This flow is within the range of a five-year average, so the study year can be considered a representative year of operation. Between 1982 and 1995, average annual flow was 265,388 million gallons (71.8% of maximum design flow) (Castro 1996, pers. comm.). Highest annual flow was in 1993 (291,156 million gallons) and lowest flow was in 1984 (231,883 million gallons) (Figure 3.6).

The 1981 study also included vertical profiles of the intake and measured screen approach velocities. Velocity measurements at the intake were taken during a cooling water flow rate of 652,000 gpm at a distance of 30 cm from the face of the trash bars. The mean approach velocity was 15 cm/sec with a maximum velocity of 30 cm/sec. Mean approach velocities across the screens was measured as well. The mean approach velocity across the traveling screens for Unit 2 averaged 21.7 cm/sec at high tide and 35.1 cm/sec during low tide; maximum measured value was 45.0 cm/sec. Unit 3 approach velocities averaged 16.3 cm/sec at high tide and 22.4 cm/sec during low tide; maximum value was 33.7 cm/sec. At Unit 6, the average approach velocity during high tide was 18.1 cm/sec and at low tide the average velocity was 25.6 cm/sec; the maximum value was 41.3 cm/sec. It should be noted that Unit 2 measurements were taken 0.3 m from the screen, Unit 3 measurements were take 1.8 m from the screen, and Unit 6 measurements taken 1.4 m from the screen.

For entrainment sampling, Unit 6 was selected as the representative unit. It was chosen for its operating history (67% capacity during the 1978-1979 study year), its flow rate of 230 mgd, and generating capacity of 343 Mw.

MARINE BIOLOGICAL SETTING

Zooplankton

Zooplankton are invertebrate adult or larval stages which are the primary grazers of phytoplankton and other organic material. In turn, they are consumed by larger, secondary consumers. Zooplankton are found throughout the water column, although certain species are characteristic at various depths. Many planktonic crustaceans undertake a daily vertical migration, swimming to the surface at night and to deeper waters during the day.

Most zooplankton species reproduce several times in a single year, the life span of an individual being measured in weeks or months. Eggs are usually dispersed throughout the water and develop through a variety of larval stages to mature adults.

Zooplankton abundances typically increase immediately following plankton blooms, especially in spring, and the subsequent grazing by zooplankton contributes to a decline in phytoplankton. However, a decline in phytoplankton is primarily caused by depletion of nutrients. The volume of zooplankton in the surface waters of the Southern California Bight generally range from 90 to 300 ml/100 m^3 (Mullin 1986). In 1980, zooplankton (mostly copepod) volumes in Santa Monica Bay ranged from 100 to 1,300 ml/1,000 m^3 (Kleppel et al. 1982).

Critical species include the copepod *Acartia*, zoeae of *Cancer* and *Neotrpyaea* spp., and the mysids *Acanthomysis macropsis*, *Metamysidopsis elongata*, and *Mysidopsis* spp.

The copepod *Acartia* was chosen as a critical species for its year-round reproductivity and its domination by density. *Acartia tonsa* and *Acartia californiensis* are two morphologically similar species which represent this taxa in the study area.

The zoeae of *Cancer* spp. (rock crabs) and *Neotrypaea* spp. (ghost shrimp, formerly *Callianassa* spp.) are common to the plankton population in the study area. These organisms are representative of the indigenous benthic community in the study area, and display seasonal reproductivity.

The mysids, represented by *Acanthomysis macropsis*, *Metamysidopsis elongata*, and *Neomysis kadiakensis*, and *Mysidopsis* spp., are an important food source for fish and most display specific day/night vertical migration patterns.

Non-critical species included other copepods, chaetognaths, larvaceans, cladocerans, other decapod zoeae, ostracods, and other mysids.

Fish Eggs

Three critical fish egg taxa were selected for the 1981 316(b) survey; they included eggs of northern anchovy, Sciaenid species complex, and *Anchoa* spp., which was comprised of *Anchoa compressa* and *Anchoa delicatissima*. Non-critical taxa included eggs from species of the genus *Pleuronichthys* and unidentified teleosts.

Ichthyoplankton

Ichthyoplankton refers to the planktonic egg and larval stages of bony fish. Most fishes release eggs and sperm in the water column. Fertilization is external, and both eggs and larvae are subject to oceanic diffusion and advection. Even among species that bear live young or attach their eggs to a substrate, the newly hatched larvae are usually pelagic.

Northern anchovy, queenfish, and white croaker are abundant nearshore spawners, as well as California halibut, sea basses, and Pacific sardine (Lavenberg et al. 1986).

Seasonality is generally a factor in abundance of certain species of ichthyoplankton, with larger concentrations of ichthyoplankton being present during and immediately after spawning seasons. Northern anchovy spawn year-round, with peaks from December to May (Love 1991). White croaker also spawn throughout the year, but most spawn from October into April, while Queenfish generally spawn between April and August (Goldberg 1976).

Between 1978 and 1979, much effort was put into characterizing the plankton population at near- and far-field stations off of the Haynes Generating Station. This information will be used to characterize zoo- and ichthyoplankton populations in the study area between 1995 and the present.

Critical ichthyoplankton were selected to represent different aspects of the plankton trophic community. The Atherinid species complex represents planktivorous fish inhabiting waters near the surface. The Engraulid species complex (anchovies) are part of an important commercially valuable fish resource. Gobiid species and the blennidae, *Hypsoblennius* spp. both represent ubiquitous, endemic bottom fish prevalent close to shore in the entire area. Larval sciaenids (white croaker and queenfish) represent the most dominant adult fish in source water. The diamond turbot represents the carnivorous bottom feeders.

Non-critical taxa included other turbots (*Pleuronichthys* spp.) and unidentified teleosts.

Field Plankton

Between 1978 and 1979, field plankton sampling was performed to characterize diel, temporal and spatial distributional patterns of critical zoo- and ichthyoplankton at near- and far-field source water stations (Figure 3.7; IRC 1981b). An entrainment mortality study was also conducted during the same time period to determine an estimate of the total number of individuals entrained annually for each critical taxa.

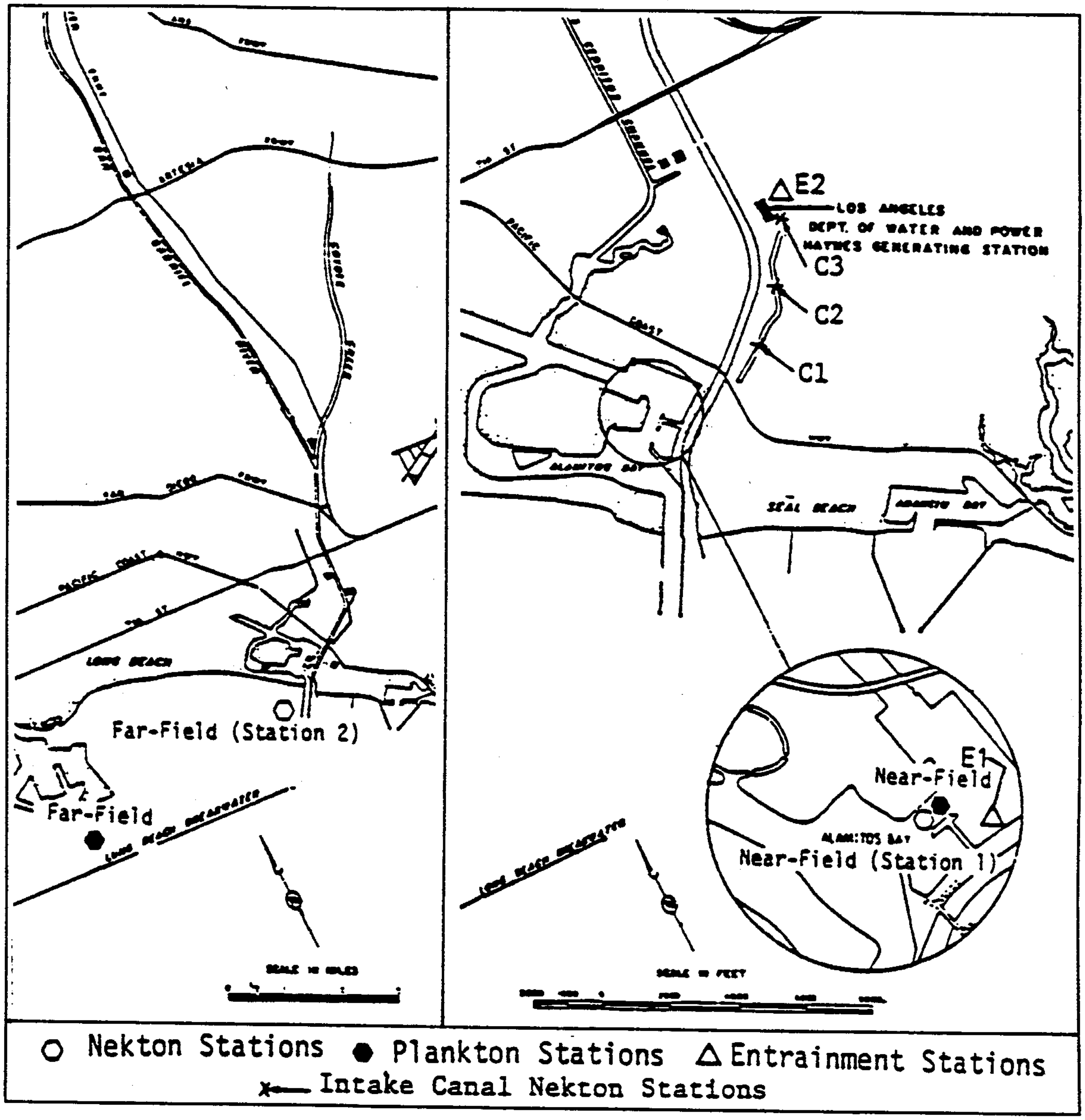

Figure 3.7. Location of near-field and far-field nekton, plankton, and entrainment stations from 1978-1979 (IRC 1981b).

Zooplankton

Seasonality. Most critical zooplankton taxa had higher observed densities during spring and summer. Only *Cancer* spp. zoeae showed no consistent pattern of abundance. This is probably because as many as five species of *Cancer*, which have overlapping breeding periods, reside in the study area. The observed seasonal patterns of abundance are consistent with results of other studies conducted in southern California waters.

Spatial Patterns. There appeared to be no consistent pattern for all zooplankton taxa. *Acartia* spp. (adults and copepodites), *Neotrypaea* spp. larvae, *Acanthomysis macropsis*, and *Metamysidopsis elongata* were most abundant at the near-field station, while *Cancer* spp. zoeae and *Neomysis kadiakensis* were most abundant at the far-field station.

Diel Patterns. Most zooplankton taxa were more abundant at night. This pattern may reflect avoidance of the sampling gear during the day, diel shifts in the stratum of greatest abundance, or movement into the water column from the bottom at night (which was common of mysids). *Neotrypaea* spp. larvae may be locally more abundant at night due to spawning patterns of gravid females. *Acartia* spp. (adults and copepodites) and *Cancer* spp. zoeae showed no consistent difference in day and night abundances.

Vertical Patterns. Most taxa of zooplankton were more abundant at mid-depth and bottom strata relative to surface concentrations. Some Mysidacea taxa studied exhibited some upward migration at night. *Cancer* spp. zoeae were found most commonly at mid-depth and bottom during the day, and at mid-depth and surface during the night, indicating some movement toward the surface during the night.

Fish Eggs

Seasonality. Most species of fish eggs were most abundant in winter and spring. However, densities for *Anchoa* spp. were similar for winter, spring, and summer. Northern anchovy eggs were most abundant in spring and summer. These results agree with spawning patterns of these species in southern California waters.

Spatial Patterns. Fish eggs showed no consistent pattern of abundance between stations.

Diel Patterns. No distinct patterns of density were revealed for the eggs of critical taxa. Greater densities observed at night for some taxa may be associated with night spawning.

Vertical Patterns. Sciaenid eggs were generally distributed evenly throughout the water column, while Engraulid eggs were most abundant at the surface and mid-depth regions of the water column.

Ichthyoplankton

Seasonality. Fish larvae were usually most abundant during winter and spring, except for atherinid larvae and queenfish larvae, which were most abundant in spring and summer. Engraulid larvae were primarily abundant from winter through spring, and exhibited a secondary period of abundance in the fall.

Spatial Patterns. Generally, Engraulid species complex, Atherinid species complex, and white croaker larvae were equally abundant at near- and far-field stations. Queenfish, *Hypsoblennius* spp., and Gobiid species complex larvae were generally more abundant in the near-field. Diamond turbot were infrequently observed and no spatial pattern was detected.

Diel Patterns. Engraulid species complex, Atherinid species complex, and queenfish larvae were generally more abundant at night. A consistent difference in day and night abundances was not observed for Gobiid species complex, *Hypsoblennius* spp., and white croaker larvae. Diel differences in density may be attributed to net avoidance by fish during the day.

Vertical Patterns. Engraulid species complex, Gobiid species complex, white croaker, and queenfish larvae were more abundant in mid-depth and bottom samples. Atherinid larvae were more abundant in surface waters than in mid-depth or bottom strata. *Hypsoblennius* spp. larvae were most abundant in surface and mid-depth collections. Generally, larger larvae were found in the lower strata.

Nearshore Fish Community

Several habitat types can be found in Alamitos Bay. Hard substrate (such as rip-rap and bulkheads) is common in the bay, as well as sand and areas of eelgrass. The intake structure for Haynes Generating Station is located in Long Beach Marina. This small-craft marina provides slips for approximately 1,800 boats (Edwards 1996, pers. comm.). Maintenance dredging occurs periodically throughout the bay.

Fish communities in Alamitos Bay have not been widely studied. An earlier study by Reish (1968) focused mainly on invertebrates. Allen and Horn (1975) studied fishes in Colorado Lagoon, located at the northwest end of Alamitos Bay. It is connected to Alamitos Bay by an underground waterway and tide gates. Storm drains empty freshwater into the lagoon, so some freshwater fish species survive there. Allen supplemented his first study with additional findings in 1976 (Allen 1976).

It is from these surveys, as well as trawl data from directly outside the bay entrance and impingement data from the 1981 316(b) demonstration, that the nearshore fish community will be characterized. Appendix H lists species identified in the separate surveys.

Northern anchovy, white croaker, and queenfish probably inhabit Alamitos Bay in large numbers. These fish form large schools throughout the Southern California Bight. Northern anchovy are one of the most abundant fishes off California, and an important prey item for many species of fishes, seabirds, and marine mammals (MBC 1987).

Perches are common in trawls throughout the Southern California Bight (MBC 1987, 1995b). Since many perches associate with submerged structures (such as outfalls), they are common in impingements at many generating stations in the Bight as well (MBC 1994a). Several species of perch have been found in Alamitos Bay, including shiner perch, white seaperch, black perch, rubberlip surfperch, walleye surfperch, barred surfperch, and pile surfperch (Appendix H).

Topsmelt and jacksmelt are common inhabitants of bays and estuaries (Love 1991), as well as deepbody and slough anchovies (Eschmeyer et al. 1983). These fish will usually be found in schools.

Pacific butterfish (pompano) is a schooling, mid-water fish.

Bottom-dwellers comprise a large majority of the Alamitos Bay fish population. California lizardfish, California scorpionfish, staghorn sculpin, and plainfin and specklefin midshipman are bottom dwellers common in the bay, and may also be found in the water column. Abundant flatfish include California tonguefish, California halibut, speckled sanddab, spotted turbot, hornyhead turbot, English sole, diamond turbot, and fantail sole (MBC 1994b,c). Round stingray, bat ray, thornback, shovelnose guitarfish, and Pacific electric ray are also common on the bottom.

Gobies are among the smallest fishes of the sea; most are under three in. long (Goodson 1988). Several species of gobies have been found in Alamitos Bay, including bay goby, yellowfin goby, arrow goby, and cheekspot goby (MBC 1994c). Gobies are taken in abundance in beam trawls throughout the bay (Vallee 1996, pers. comm.).

INTERRELATIONSHIP OF PHYSICAL, OCEANOGRAPHIC, AND GENERATING STATION EFFECTS

This section discusses the interrelationship of the marine ecosystem and effects created by the existing cooling water intake system of the Haynes Generating Station.

Source Water Characteristics

Alamitos Bay is almost continuously supplied with ocean waters induced by tidal currents or cooling water withdrawal from the inner part of the bay. However, cooling water entrainment from the bay poses a potentially hazardous environment for the offspring of the bay's inhabitants, as well as for the offspring of species who use the bay as a spawning ground.

The Haynes Generating Station requires 44.7% of the cooling water drawn into Alamitos Bay. The portion of oceanic water entrainment in the Haynes Generating Station from a point at the bay entrance is about 32.2% of the water passing that location.

The bay provides shelter for certain life forms from violent wave motion. The intertidal perimeter and bottom of Alamitos Bay provide diverse substrates, ranging from mud, through sand, to rock rubble. Although the bay is protected from forceful high-frequency motions, a subtidal net mass transport through the bay brings circulated food and oxygen. Mixing within the bay is relatively accelerated by bottom boundary irregularities and strong tidal and intake-induced currents. Physical measurements have indicated that water masses become progressively better mixed as they are drawn from the outer bay toward the cooling water intakes.

Field plankton data shows that near- and far-field stations were often equivalent in population densities, and nearly half of the species studied were more abundant in the near-field.

Habitat Preference

Distributional strategies and habitat preference of specific taxa determine the extent to which the operational requirements of a generating station can influence source water populations.

Zooplankton

Copepods of the genus *Acartia* are cosmopolitan and inhabit bays, estuaries and coastal waters throughout most of the world. By nature of their distribution, the effect of entrainment on *Acartia* sp. would be diluted over a large area having a longshore configuration within the neritic waters of southern California.

Of the mysids studied, only *Neomysis kadiakensis* is considered mainly an open-water species. Therefore, entrainment effects upon this organism are likely manifested as small depletions dispersed over a fairly large area, most likely within the Southern California Bight. The other mysids (*Acanthomysis macropsis*, *Metamysidopsis elongata*, and *Mysidopsis* spp.) are considered inshore species. However, entrainment effects of these taxa will be more concentrated within Alamitos Bay and the nearshore areas immediately outside the bay. The bay habitat preference of these three taxa is reflected in the higher near-field densities as compared to the far-field.

Zoeae of the *Cancer* spp. crabs are often associated with the open coast or outer bays within the vicinity of rock jetties. Entrainment losses of this taxa will effect populations offshore and downcoast of the generating station, which depend upon recruitment of this taxa from upcoast regions.

The distributional pattern of *Neotrypaea* spp. zoeae reflects the distribution of burrowing adults in the substrate of shallow bay waters, as opposed to deeper waters of outer bays. This distributional pattern will tend to concentrate entrainment loss effects within the confines of Alamitos Bay, and, to some extent, shallow inshore areas in close proximity to the bay entrance.

Ichthyoplankton

White croaker, queenfish, and northern anchovy are common throughout the Southern California Bight in both open coast and bay environments. Spawning occurs over a large geographic area and eggs and larvae become widely dispersed. Extremely high fecundity and high natural mortality rates for larvae are characteristic of these fishes. For these species, reduced recruitment due to entrainment of larvae could affect a large geographic area; however, local magnitude of the impact would be greatly reduced by mixing and dilution.

At the other extreme are larvae of the Gobiid species complex. Adult gobiids are territorial and show no significant movement away from an area of initial settlement. According to Brothers (1975), removal of gobiid larvae from bays by tidal currents represents a major source of mortality. Similarly, Blennidae larvae may also suffer high mortality for the same reasons. Based on these features of their life history, it is assumed that for the gobiid species complex and *Hypsoblennius* spp., recruitment to the adult population relies on larvae spawned nearby. Thus, entrainment losses would be expected to have a more pronounced effect than seen for other open water fish which disperse eggs and larvae and, as adults, range over a large area. For *Hypsoblennius* spp. and Gobiid species complex, reduced recruitment due to egg and larval entrainment would probably be most evident within the bay. Egg and larval production is so high in this area that a small decrease in the number of larvae which might be transported in the bay (an unlikely event) would not be significant.

Critical taxa such as diamond turbot, Engraulid species complex, and Atherinid species complex exhibit life histories intermediate of the two extremes discussed above.

IMPACT ASSESSMENT

Total Losses

Estimates from the 1978-1979 entrainment studies were determined by integrating densities at the near- and far-field stations (IRC 1981b). Three annual mortality estimates are given for each taxa of ichthyoplankton and zooplankton. Near-field (NF) and far-field (FF) densities are combined to give high- and low-end estimates of population densities. A ratio of NF (1.0) and FF (0.0) uses the near-field densities to compute entrainment loss ratios, while the ratio NF (0.0) and FF (1.0) uses far-field densities; the ration NF (0.5) and FF (0.5) averages near- and far-field densities (Tables 3.1 and 3.2).

Table 3.1. Near-field and far-field zooplankton densities, mean daily zooplankton entrainment losses, and estimated loss ratios using near-field, far-field, and combined densities (IRC 1981b).

Taxa	Near-Field Mean Density (per cubic meter)	Far-Field Mean Density (per cubic meter)	Mean Daily Entrainment Loss x 1,000,000	NF (1.0) FF (0.0)	Loss Ratios @ NF (o.5) FF (0.5)	NF (0.0) FF (1.0)
Acartia spp. (adults)	2222.3	3092.8	2080	0.028	0.023	0.019
Acartia spp. (copepodites)	3844.7	2880.7	3230	0.025	0.028	0.033
Metamysidopsis elongata	171.9	1.1	234	0.04	0.079	6.25
Neomysis kadiakensis	0.7	7.4	2.3	0.097	0.017	0.009
Cancer spp. (zoeae)	0.6	13.6	8.85	0.043	0.004	0.002
Callianassa spp. (zoeae)	177.5	24.5	50.5	0.008	0.015	0.061

NF - Near-Field FF - Far-Field
Acartia spp. includes 19 of 26 surveys

Table 3.2. Near-field and far-field ichthyoplankton densities, mean daily ichthyoplankton entrainment losses, and estimated loss ratios using near-field, far-field, and combined densities (IRC 1981b).

Taxa	Near-Field Mean Density (per cubic meter)	Far-Field Mean Density (per cubic meter)	Mean Daily Entrainment Loss	NF(1.0) FF(0.0)	Loss Ratios @ NF (0.5) FF (0.5)	NF(0.0) FF(1.0)	Equivalent Adult Losses
Larvae							
Atherinid Species Complex	0.1	0.06	33400	0.009	0.012	0.016	22200
Engraulid Species Complex	0.84	0.88	1670000	0.065	0.064	0.062	29600
Gobiid Species Complex	2.19	0.39	8630000	0.116	0.197	0.651	165000000
Hypsoblennius spp.	1.38	0.13	12100000	0.268	0.471	2.73	370000
Genyonemus lineatus	0.51	0.5	569000	0.033	0.033	0.033	46900
Seriphus politus	0.19	0.04	146000	0.023	0.037	0.107	560
Eggs							
Engraudis mordax	0.31	1.71	624000	0.069	0.018	0.011	5850
Sciaenid Species Complex	8.71	8.49	7010000	0.024	0.024	0.024	169000000

NF - Near-Field FF - Far-Field

Zooplankton

Mean daily entrainment losses for *Acartia* spp. adult and copepodites are estimated to be between 1.9 and 3.3% (Table 3.1). Considering the high reproductive potential for this organism, these losses are considered insignificant. Entrainment loss ratios for *Metamysidopsis elongata* were between 0.04 and 6.25, reflecting higher near-field densities in Alamitos Bay. When weighting estimates more towards near-field densities, an estimate of between 4.0 and 7.9 percent of organisms lost to entrainment is more likely. Loss ratios of *Neomysis kadiakensis* are between 0.009 and 0.097, while ratios for *Cancer* spp. zoeae are between 0.002 and 0.043. Since these species are more likely to be found in far-field areas, weighing densities towards the far-field gives plant-induced mortality rates of 0.9 to 1.7 percent for *Neomysis kadiakensis*, and 0.2 to 0.4 percent for *Cancer* spp. zoeae. Conversely, *Neotrypaea* spp. zoeae are more likely to be found in near-field areas. Weighting densities towards near-field values produces plant-induced loss estimates of 0.8 to 1.5%. None of these loss estimates are considered to be significant.

Fish Eggs

Loss ratios for northern anchovy ranged from 0.011 to 0.059, and were higher in the near-field (Table 3.2). Ratios for Sciaenid species complex were the same at near- and far-field sites (0.024). These losses are considered insignificant due to high reproductive potential, high natural mortality rates and restricted time eggs are in the plankton (low susceptibility).

Ichthyoplankton

Loss ratios for ichthyoplankton are presented in Table 3.2. Loss ratios weighted towards primary habitat of each species indicate no apparent significant losses due to the operation of the Haynes Generating Station. Equivalent adult losses from the loss of fish larvae are also estimated in Table 3.2. Losses of fish eggs and larvae to the Haynes Generating Station are offset by high reproductive potentials and recruitment from neighboring areas.

A report developed by the Electric Power Research Institute (EPRI) in 1979 used the following points to argue the statement that likened generating stations to marine predators of plankton: 1) The rapid reproduction potential of plankton permits relatively rapid replacement of individuals killed during entrainment. Because organisms are replaced rapidly, the impact on the ecosystem is negligible. 2) The individuals killed during the entrainment processes are not lost to the system, but are recycled through decomposition processes. 3) Plankton populations are transient and losses in a given area will be replaced by mixing of the discharged water with unimpacted water masses. 4) Plankton are opportunistic colonizers and highly resilient to perturbations. Extinction or exclusion of such forms due to power plant operation is, therefore, unlikely.

Fish

Based upon 191 days of impingement sampling between 1978 and 1979, estimated daily losses of queenfish and shiner perch are presented in Table 3.3. Standing stock estimates were calculated using 12% and 30% trawl efficiencies, and daily cropping rate estimates are presented in Table 3.3. Losses of less then 0.1% for both species are considered insignificant.

Table 3.3. Mean number of queenfish (*Seriphus politus*) and shiner perch (*Cymatogaster aggregata*) impinged daily, adult fish mortality at 12% and 30% trawl efficiencies, and percent of standing stock cropped per day by Haynes Generating Station (IRC 1981b).

Taxa	Mean Number Fish Impinged Daily	Trawl Efficiency		% Standing Stock Cropped per Day	
		12%	30%	12%	30%
Seriphus politus	2	0.00000051	0.0000002	<0.1	<0.1
Cymatogaster aggregata	31	0.0011	0.00046	<0.1	<0.1

Standing stock and natural mortality rates of critical taxa showed no significant effect from the operation of the Haynes Generating Station. The principle loss of plankton through biological predation in the canal/conduit system transfers energy to a higher trophic level. Source water fish populations displayed normal distributions and reproductive periods.

BEST TECHNOLOGY AVAILABLE

Analysis of data collected during 1978 and 1979 showed Haynes Generating Station was minimizing adverse environmental effects through the use of best technology available. Low impacts from entrapment and impingement demonstrated insignificant losses to marine life in the surrounding waters.

The California State Water Resources Control Board's 316(b) Guidelines (1977) classified cooling water intake systems as low, medium, or high potential impact. Criteria used in classifying impacts included the following: 1) Fish mortality of over 30,000 lbs per year; 2) intake situated in an area of very high value aquatic habitat; 3) intake volume over 1,500 cfs; 4) entrainment period long due to conduits; 5) local presence of rare, endangered, or threatened aquatic species; and 6) intake volume relatively low - plant less than 100 MW capacity. Prior to the original 316(b) survey, Haynes was tentatively classified by the state as an intermediate impact power plant due to its large intake volume (over 1,500 cfs). The demonstrated low entrainment and impingement values suggest the criteria of intake volume may not be representative of any environmental impact.

Criteria number one was not exceeded during the 1978-1979 survey; the projected impingement loss of approximately 3,000 lbs per year is substantially less than 30,000 lbs per year. Criteria number two and number five are not applicable to Haynes Generating Station. Alamitos Bay is inhabited by species common to southern California coastal waters. The location of the Haynes Generating Station intake structure does not affect rare, endangered, or threatened aquatic species. Criteria number four (entrainment period long due to conduit lengths) could apply to the Haynes Generating Station. Plankton losses in the conduit/canal system, however, have been shown to result mainly from predation and grazing. Criteria number six does not apply to the Haynes Generating Station.

For the above reasons, no alternative intake technologies were addressed. Cooling water flow since the original 316(b) survey has remained at approximately the same annual volume. Losses of plankton and fish at the Haynes Generating Station are likely minimized by the intake technology currently in use.

CHAPTER 4
HARBOR GENERATING STATION

HARBOR GENERATING STATION

CHARACTER OF THE STUDY AREA

Los Angeles-Long Beach Harbor encompasses approximately 6,000 acres at the southeastern base of the Palos Verdes Peninsula in Los Angels County, and is bounded by the cities of San Pedro, Wilmington, and Long Beach. Seaward it is bounded by the San Pedro, Middle, and Long Beach breakwaters. The central part of the harbor complex is Terminal Island, which was modified by landfill extensions from the natural Rattlesnake Island.

The Port of Los Angeles has 3,137 acres of land (USACE 1990). Containerized cargo and dry bulk terminals are found in the Terminal Island Los Angeles Channel area, while liquid bulk facilities can be found in the West Channel, off the Main Channel near the West Turning Basin, and in the Wilmington District.

The Harbor Generating Station is located in the Inner Los Angeles Harbor complex (Figure 4.1). Cooling water is drawn from Slip 5, southeast of the plant, and discharged into the West Basin. Intake and discharge sites are entirely surrounded by dockage, wharfage, ship-building and repair facilities, reflecting the industrial composition of Los Angeles-Long Beach Harbor. The northern portion of the harbor is used for limited recreational boating while the West Basin is utilized for oil transfer from land to ship and ship to land.

Topography of Los Angeles Harbor

The bottom topography of Los Angeles Harbor is relatively uniform. The bottom is generally covered by a meter of silt. Ship channels in the harbor are maintained to approximately 18 m by dredging.

Climate

Air Temperature

The climate of southern California is Mediterranean, characterized by warm, dry summers and mild, wet winters. Although less than half of the days of the year are cloudy, insolation (i.e., sunshine) is greatest from March to September. The sun heats the air, land, and water; in turn, the land and water heat the air. The average daily (24 hr) air temperature in the study area ranges from 45 to 72°F annually (SCCWRP 1973), being coldest in January and warmest in July.

A temperature inversion often develops on the Los Angeles Coastal Plain during the summer. Cool coastal air is trapped beneath warm air at higher altitudes, resulting in hazy or smoggy air. Cool air over upwelling regions of the ocean often results in fog. During late spring and early summer, fog may deepen to several thousand yards, causing drizzles throughout the Coastal Plain (Miller and Hyslop 1983).

Rainfall

The average annual rainfall on the Coastal Plain is 12 to 13 in., about 90% of which occurs between November and April (SCCWRP 1973, Kimura 1974, Miller and Hyslop 1983). In winter, cold-front storms typically come from the northwest; in summer, tropical storms called

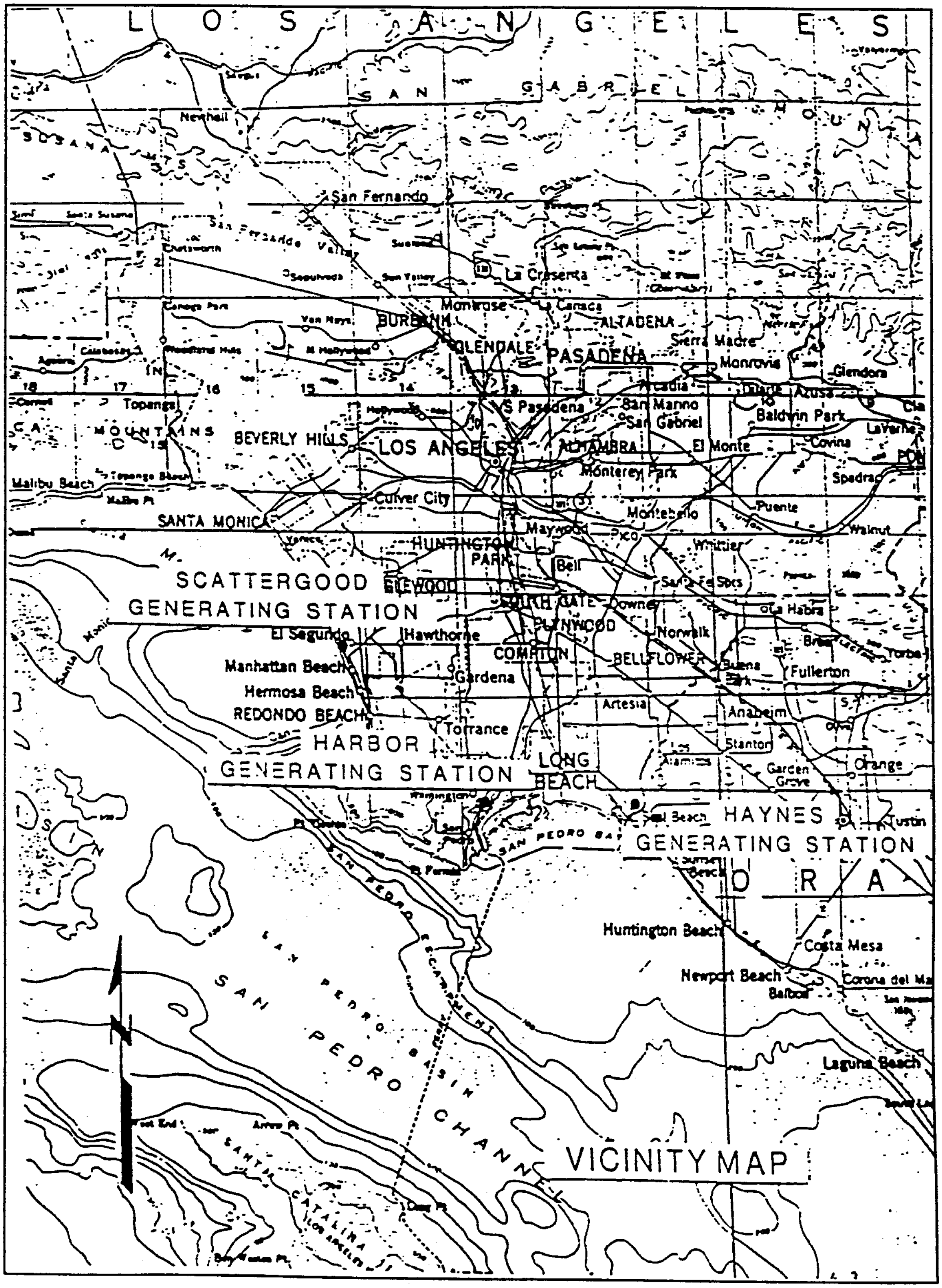

Figure 4.1. Location of Harbor Generating Station (IRC 1981c).

"chubascos" occasionally come from the southeast. Most storms originate over the ocean as low pressure cells, but thunderstorms occasionally result from hot air rising over land (Kimura 1974, Miller and Hyslop 1983).

Wind

Prevailing winds along the coast are from the west-northwest and wind speed is generally low throughout the year. In summer, sea breezes typically blow onshore in the morning as air over the land heats up, rises, and pulls cool air from the ocean (Miller and Hyslop 1983). At night, offshore land breezes often develop as air over the land is pulled seaward while air over the warmer ocean rises.

During winter (but occasionally at other times), hot, dry Santa Ana winds blow to the west off the deserts east of the Los Angeles Basin. These gusty winds result from high pressure cells over the desert and enter the coastal zone through mountain passes.

El Niño Events

Every so often, with a quasiperiodicity of three to five years (Graham and White 1988), the oceanic environment of southern California changes dramatically as an El Niño Southern Oscillation event takes place. During an El Niño, the normal water mass off the California coast is replaced by water which is warmer, more saline, and lower in nutrients than usual. These conditions extend through the water column and may persist for months or years.

El Niños result from large-scale changes in the climate and oceanography of the Pacific Ocean as a whole. Normally, tradewinds north of the Equator, which blow to the west, force water to accumulate in the western Pacific. When tradewinds weaken, seawater flows easterly (as a long-period wave). When this wave encounters the Americas, it moves both north and south along the coast. Because currents in the North Pacific also decrease in strength, the south-flowing California Current is weakened and the warm-water mass from equatorial latitudes penetrates into the Southern California Bight. The most recent large El Niño event was in 1982-1983, with the previous large El Niño in 1957-1959. Events of lesser magnitude occurred in 1986-1987 and in 1991-1992 (Radovich 1961, Graham and White 1988, Kerr 1992, Tegner et al. 1995).

During an El Niño, marine organisms with more southern distributions occur in the Bight, whereas cold water species become less abundant: pelagic red crabs, which are normally found off southern Baja California, were abundant offshore southern California in 1982 and 1983. During an El Niño, the sport and commercial fisheries (and success) for pelagic species such as yellowtail, bluefin, yellowfin, bigeye and skipjack tuna, bonito, and dorado may increase dramatically. However, albacore may shift northward, along with Pacific mackerel, which then impact the northern fisheries by preying on newly-arriving young salmon.

El Niño periods are also frequently characterized by stronger-than-normal winter storms accompanied by large waves which destroy coastal structures, erode beaches, and churn up the nearshore environment. Sediment carried by terrestrial runoff and suspended by wave activity can persist along the coast, reducing visibility, and algal and phytoplankton growth. Reduced nutrient levels accompanying an El Niño can result in a decline in kelp beds (Tegner et al. 1995, Dailey et al. 1993), decreasing habitat available to fish communities dependant on the kelp.

Oceanography

Currents

At the Harbor Generating Station, local currents are determined by a combination of wind, thermal structure, and local topography. An estimate may be made of the volume of water moving in and out of the harbor based on two tide changes per day, average tidal fluctuation, average depth, and harbor area. A considerable portion of the water leaving the harbor on an ebb tide enters on the next flood tide, however. Therefore, residence time of water in the upper reaches in the harbor is relatively long because of the limited opportunity for direct exchange with ocean water.

Tides

Tides along the California coast are mixed semi-diurnal, with two unequal highs and two unequal lows during each 25-hr period. In the case of a harbor environment, flood tide flows into the harbor and upchannel, and ebb tide flows downchannel and out of the harbor.

Upwelling

During prolonged northwesterly winds in winter and spring, nearshore surface water is transported offshore along coasts with a northwest-southeast orientation (Dailey et al. 1993). Wind-induced friction causes the nearshore surface waters to begin moving offshore. Once moving, the Coriolis effect deflects water further offshore (Garrison 1993). Subsequently, nearshore waters are replaced by deep, oxygen-poor and nutrient-rich waters. This process is important because the nutrient-rich waters stimulate plankton productivity, the primary component of the marine food web. Frequently, patches of cold water in response to upwelling have occurred in Santa Monica Bay and over the San Pedro shelf, but generally occur less frequently and less intensely than in other coastal areas north of Point Conception (Dailey et al. 1993).

Characteristics of Seawater

Temperature

Temperature variations of coastal waters are significantly greater than those of the open ocean because of the relative shallowness of the water, influence from land runoff, localized upwelling, and turbulence generated by current and wave action. Factors contributing to the rapid daytime warming of the sea surface include weak winds, clear skies, and warm air temperature. Conversely, overcast skies, moderate air temperature, and vertical mixing of surface waters by winds and waves limit daily warming. Natural surface water temperatures in San Pedro Bay range annually from 55 to 78°F (EQA/MBC 1977). During summer months, a thermocline (strong temperature gradient with depth) may develop as a result of warming of surface waters from insolation.

Salinity

Salinity is relatively constant in the open ocean. However, in coastal environments it fluctuates as a result of the introduction of freshwater runoff, direct rainfall, and evaporation (EQA/MBC 1977). The usual range for Los Angeles-Long Beach Harbor is 30.0 to 34.2 ppt, with greatest variations observed in the inner harbors. Maximum values are generally observed in summer and minimum values are usually seen during winter storms (USACE 1990).

Density and Stratification

Seawater density varies inversely with temperature and directly with salinity at a given pressure. Water temperature is the major factor influencing density stratification in southern California since salinity is relatively uniform. As a result, density gradients are most pronounced when spring and summer thermoclines are present.

Transparency to Light

The depth to which light will penetrate the ocean is dependant on numerous factors, including the absorption of light by water, the wavelength of light, transparency of the water, reflection from the water surface, suspended particles in the water column, latitude, and season of year. Water transparency (as measured by a standard Secchi disk) generally ranges from 6 to 15 m in southern California, with the lowest values occurring close to shore. A band of low transparency water is characteristic within about 1.6 km of the shore.

Light penetration is especially important to photosynthesis. Most photosynthesis occurs in the mixed layer, from the surface to water depths of about 11 m (MBC 1993b). This area is referred to as the photic zone. As light levels decrease photosynthesis decreases. The lower boundary of the photic zone is referred to as the compensation depth; no photosynthesis occurs here. Sunlight intersects the sea surface at a steeper angle in summer than in winter; thus, light penetrates more deeply in summer and the photic zone is deeper. Transparencies are generally lower during spring than during fall, probably due to an increase in freshwater runoff from land (SCCWRP 1973).

As light penetrates seawater, it is reflected, absorbed, or scattered. The depth of light penetration is greatest in transparent waters and least in turbid waters. Annual mean water transparency in Long Beach Harbor between 1971 and 1990 ranged from 1.8 to 3.7 m (MBC 1992b).

Hydrogen Ion Content (pH)

The pH of seawater is maintained by the buffering effect of the salts of carbonic acid and the salts of other weak acids and strong bases. Normal pH values in Los Angeles Harbor adjacent to the Harbor Generating Station range between 7.7 and 8.4 (MBC 1994d).

Dissolved Oxygen

Dissolved oxygen (DO) is utilized by aquatic animals in their metabolic processes and is replenished in the ocean by gaseous exchange with the atmosphere and as a by-product of photosynthesis. Surface water DO concentrations in Los Angeles Harbor adjacent to the Harbor Generating Station normally range from 4 to 9 mg/l (MBC 1994d). High concentrations can result from active photosynthesis and low values from decomposition of organic material and vertical mixing of surface waters with oxygen poor subsurface waters.

GENERATING STATION DESCRIPTION

Location

Harbor Generating Station is located on the southern California coast in the City of Los Angeles (Figure 4.2). Seawater utilized in the once-through cooling system is withdrawn from Slip

Figure 4.2. Harbor Generating Station intake and discharge lines (IRC 1981c).

No. 5 of the Los Angeles Harbor through an intake structure located in the pier bulkhead. Water is conveyed through a pair of closed conduits approximately 335 m to the screen and pump chamber at the generating station. After passing through the station, the heated cooling water is discharged through a submerged structure to the West Basin of the harbor.

The Department has two other generating stations along the Southern California coast that utilize sea water for once-through cooling. In addition, the Southern California Edison Company operates the Long Beach Generating Station which has its intake structure located approximately 5.3 km from the harbor intake.

Station Description

Harbor Generating Station originally consisted of five steam electric units. The first unit was brought on-line in 1943, with subsequent units added until the fifth and final unit was placed into operation in 1949. Unit 1 had a capacity of 72 Mw. Unit 2 had a capacity of 67 Mw, and Units 3, 4, and 5 had a capacity of 86 Mw each. Total steam generating capacity was 398 Mw until 1991. At that time, Units 1 and 2 were decommissioned and removed, lowering total plant capacity to 258 Mw. In October 1991, Units 3, 4, and 5 were deactivated for plant upgrades which were not completed until the latter part of 1993.

Steam is supplied to the units from separate boilers that may be fired by either oil or gas. In addition to the steam electric generating units, four gas turbine-generators were installed at the plant in 1972. These units may be fueled by either natural gas or a light distillate fuel oil. They are cooled by a closed-cycle radiator system. All liquid wastes from the operation and maintenance of these generators are directed to an oil-water separator which is eventually discharged into the city sewer system.

Cooling Water Intake System

All units at the Harbor Generating Station share a common cooling water intake system. Water is drawn from the northwest corner of Slip No. 5 through a 17-m wide by 3-m high intake structure from an approximate depth of 3.4 to 6.4 m MLLW at a maximum design velocity of 30 cm/sec (Figure 4.3). Six vertical bar racks consisting of 3/8-in. by 3-in. bars spaced 4.5 in. on center prevent large debris from entering the system.

Seawater is conveyed from the intake structure through two 2.4-m diameter reinforced concrete pipes a distance of 335 m to the screen and pump chamber (Figure 4.4). Six conventional 5/8-in. mesh vertical traveling screens are used to prevent trash and small marine organisms from entering the cooling system. Design velocity through the screens is 0.6 m per second. The traveling screens are rotated once every eight-hour shift for approximately thirty minutes for debris removal. Debris collected on the traveling screens is removed by high pressure sprays and emitted in trash baskets for disposal.

Each unit has two circulating pumps, one for each condenser half. The pumps for Units 1 and 2 are vertical single-stage, manufactured by Pomona, and operate at a design flow of 24,000 gpm at 709 revolutions per minute (RPM) at a head of 31 ft. Units 3, 4, and 5 utilize vertical single-stage pumps, manufactured by Peerless, and operate at a design flow of 30,000 gpm at 514 RPM at a head of 25 ft. Average monthly flow between March 1990 and August 1994 was 322 mgd, and average maximum flow during the same period was 391 mgd (NPDES permit). The discharged effluent consists of once-through cooling water, treated chemical metal cleaning wastes, and low volume wastes (NPDES permit). Chemical metal cleaning wastes are collected

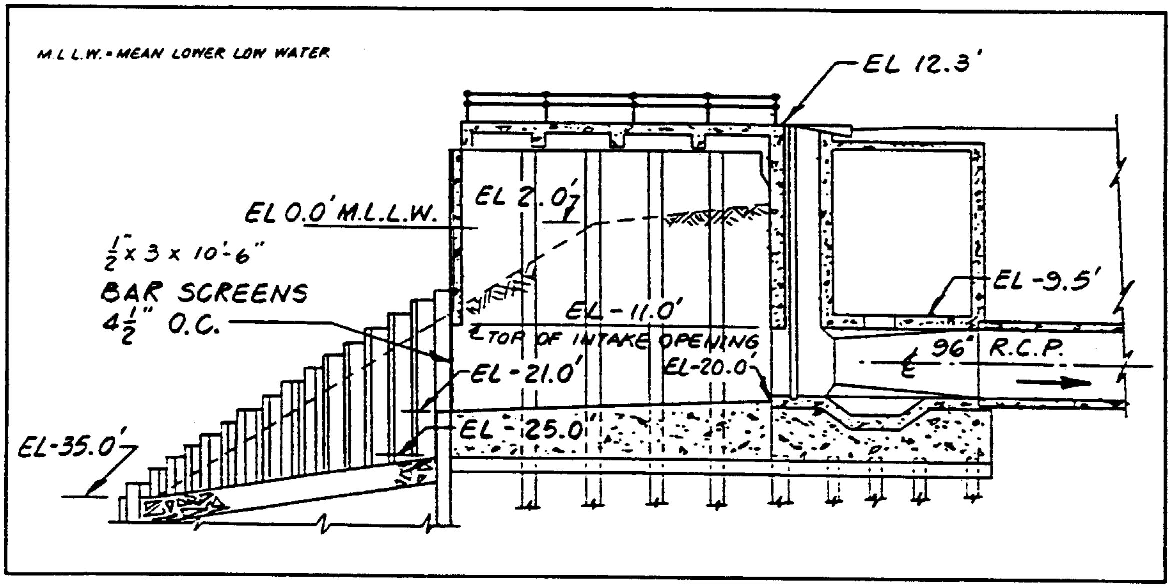

Figure 4.3. Harbor Generating Station circulating water intake structure (IRC 1981c).

and treated in portable Baker tanks. They are then sent to a settling sump where they combine with low volume wastes before being discharged. Residues in the basins and from chemical cleaning wastes are periodically transported to legal disposal sites.

The design temperature differential for the cooling water as it passes through the condensers is 12°F for Units 1 and 2, and 15°F for Units 3, 4 and 5. After the cooling water has passed each condenser half, it is discharged into a two-sided chamber running the length of the station. From this discharge chamber, the water is conveyed through two 2.4-m diameter underground conduits approximately 490m to a submerged multiport discharge structure located in the pierhead near the northeast corner of the West Basin of the Los Angeles Harbor (Figure 4.4).

Cooling Water Intake System Operations

During periods of generation, marine fouling growth is controlled by the use of chlorine. Chlorine is injected each eight-hour shift for 15 minutes per condenser half. Chlorine concentrations at the discharge structure are maintained at a level to be in compliance with existing NPDES permit limitations (CRWQB 1995c). All other in-plant waste streams are discharge to the city sewage system and do not contribute to the cooling water discharge.

During periods of non-generation, marine biofouling is controlled by placing stop logs at various locations in the circulating water system. Anaerobic conditions result and the dead fouling organisms are subsequently removed.

A portion of the cooling water from each unit is diverted prior to reaching the main steam condensers and is channelled to auxiliary cooling water heat exchangers which are used to cool bearings and other auxiliary plant equipment. After passing through the heat exchangers, the water is combined with the main condenser cooling water and discharged into the harbor.

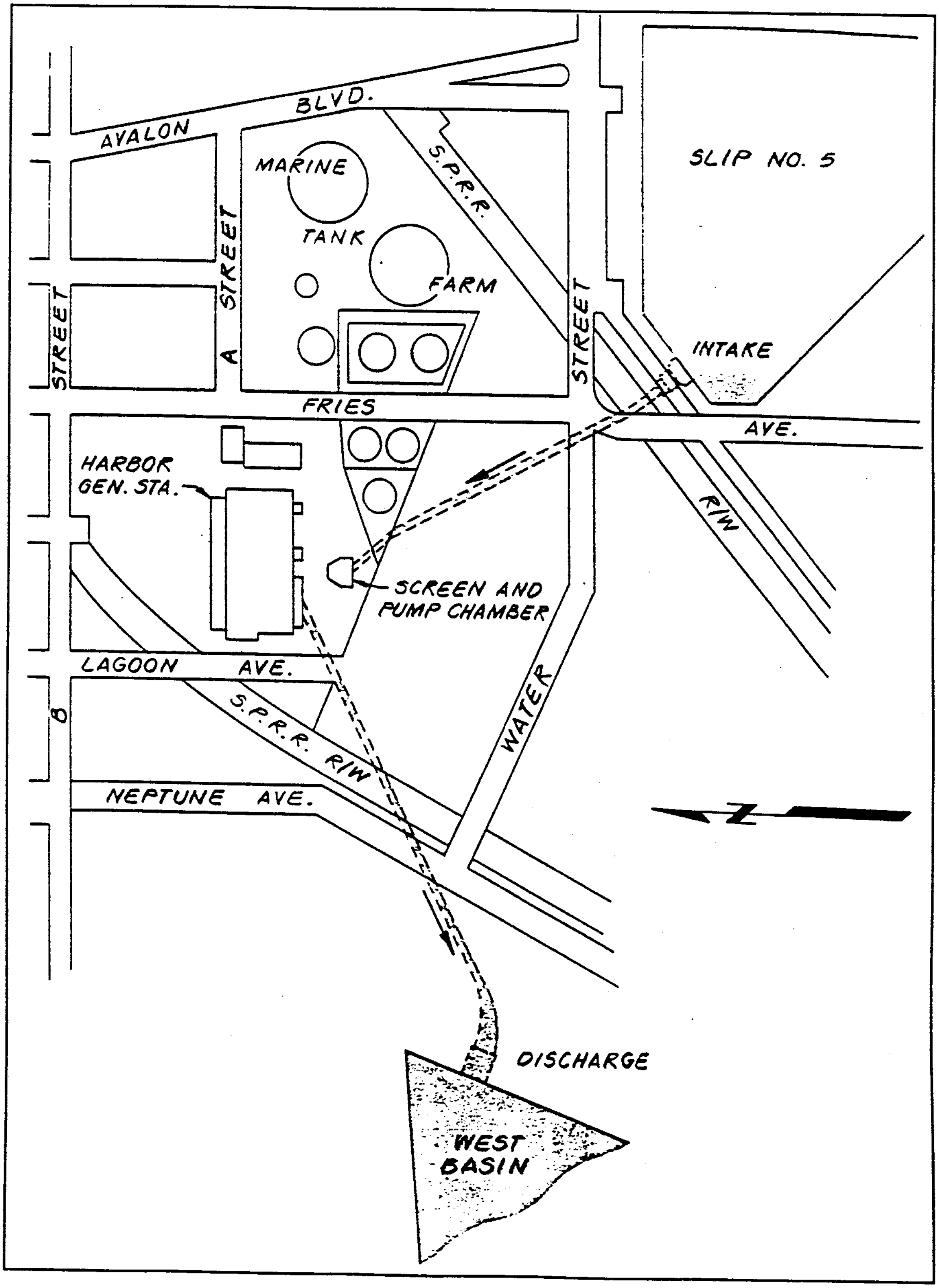

Figure 4.4. Harbor Generating Station circulating water intake and discharge lines (IRC 1981c).

Study Period Operating Characteristics

Operating characteristics for Harbor Generating Station between 1981 and 1995 can be best described by analysis of the generating capacity factors and the cooling water flow data. The capacity factor is a comparative measure of the actual plant generation to the plant generation capability. However, yearly or monthly capacity factors are a very general measure of operating characteristics. Daily and hourly generation fluctuations are not discernable from these values. Generating fluctuations can indicate cooling water temperature differentials with a corresponding effect on entrained organisms.

Cooling water flow is a better indicator of the station's operations and its effect on entrained organisms. A direct relationship exists between cooling water flow and the number of organisms entrained.

Operating characteristics for the period October 1978 through September 1979 were described in detail in Harbor Generating Station's 1981 316(b) Demonstration Study (IRC 1981c). During that period, the capacity factor for the plant averaged 20%, compared with a 10% average during the 10 years prior to the study period. The winter peak load was February 1979 (38% capacity) and the summer peak load was September 1979 (35% capacity). Available capacity data from 1986-1995 shows average plant capacity was approximately 7%. It should be noted, however, that there are several data gaps in the capacity information, including 10 months from 1995, eight months from 1994, and four months from 1991. Plant capacities ranged from zero (several months, including 1992 and 1993) to 40.04% in March 1995.

Total flow during for the period October 1978 through September 1979 was 86,652 million gallons (62% of maximum flow), which is over twice the five year average flow for the station. This increase in flow reflected increased power generation during the study year, as well as requirements of the study. Entrainment sampling, fish impingement collection, and physical oceanographic studies required cooling water pumps to be in operation during periods of no generation. Therefore, it must be noted that any impact Harbor Generating Station had on the number of organisms entrained and impinged during the study year represents the "worst case." Since 1981, total annual flow at Harbor Generating Station has averaged 44,307 million gallons (32% of maximum design flow), ranging from approximately 5,000 million gallons in 1992 (a year when no units were on-line, and only 291 days of data were available) to 74,470 million gallons in 1986 (53% of maximum design flow) (Figure 4.5).

The 1981 study also included vertical profiles of the intake and measured screen approach velocities. Velocity measurements at the intake were taken during a cooling water flow rate of 397 mgd (maximum flow) to represent the maximum expected approach velocity. The mean approach velocity over the 3-m intake opening was 50 cm/sec with a maximum velocity of 68 cm/sec. The mean approach velocity across the traveling screens was less than 30 cm/sec, and depending on screen location, maximum values varied from 50 to 105 cm/sec.

MARINE BIOLOGICAL SETTING

Zooplankton

Zooplankton are invertebrate adult or larval stages which are the primary grazers of phytoplankton and other organic material. In turn, they are consumed by larger, secondary consumers. Zooplankton are found throughout the water column, although certain species are characteristic at various depths. Many planktonic crustaceans undertake a daily vertical migration, swimming to the surface at night and to deeper waters during the day.

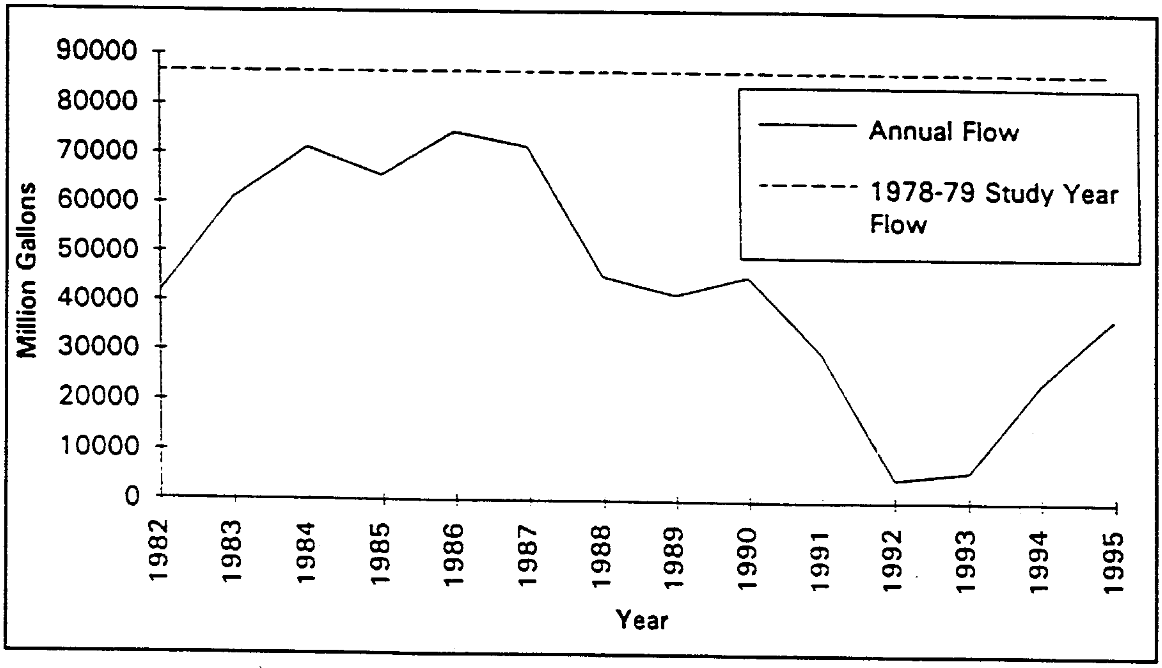

Figure 4.5. Comparison of Harbor Generating Station annual circulating water flow (million gallons) and annual circulating water flow from 1978-1979 study year.

Most zooplankton species reproduce several times in a single year, the life span of an individual being measured in weeks or months. Eggs are usually dispersed throughout the water and develop through a variety of larval stages to mature adults.

Zooplankton abundances typically increase immediately following plankton blooms, especially in spring, and the subsequent grazing by zooplankton contributes to a decline in phytoplankton. However, a decline in phytoplankton is primarily caused by depletion of nutrients. The volume of zooplankton in the surface waters of the Southern California Bight generally range from 90 to 300 ml/100 m^3 (Mullin 1986). In 1980, zooplankton (mostly copepod) volumes in Santa Monica Bay ranged from 100 to 1,300 ml/1,000 m^3 (Kleppel et al. 1982).

Critical species include the copepod *Acartia*, zoeae of *Cancer* and *Neotrypaea* spp., the mysids *Acanthomysis macropsis*, *Metamysidopsis elongata*, *Mysidopsis* spp., and *Neomysis kadiakensis*.

The copepod *Acartia* was chosen as a critical species for its year-round reproductivity and its domination by density. *Acartia tonsa* and *Acartia californiensis* are two morphologically similar species which represent this taxa in the study area.

The zoeae of *Cancer* spp. (rock crabs) and *Neotrypaea* spp. (ghost shrimp, formerly *Callianassa* spp.) are common to the plankton population in the study area. These organisms are representative of the indigenous benthic community in the study area and display seasonal reproductivity.

The mysids, represented by *Acanthomysis macropsis*, *Metamysidopsis elongata*, *Mysidopsis* spp., and *Neomysis kadiakensis*, are an important food source for fish and most display specific day/night vertical migration patterns.

Non-critical species included other copepods, chaetognaths, larvaceans, cladocerans, other decapod zoeae, ostracods, and other mysids.

Fish Eggs

Three critical fish egg taxa were selected during the 1981 316(b) demonstration; they included northern anchovy, Sciaenid species complex, and *Anchoa* spp., which was comprised of the species *Anchoa compressa* and *Anchoa delicatissima*.

Non-critical taxa included eggs of *Pleuronichthys* spp. and unidentified teleosts.

Ichthyoplankton

Ichthyoplankton refers to the planktonic egg and larval stages of bony fish. Most fishes release eggs and sperm in the water column. Fertilization is external, and both eggs and larvae are subject to oceanic diffusion and advection. Even among species that bear live young or attach their eggs to a substrate, the newly hatched larvae are usually pelagic.

Northern anchovy, queenfish, and white croaker are abundant nearshore spawners, as well as California halibut, sea basses, and Pacific sardine (Lavenberg et al. 1986).

Seasonality is generally a factor in abundance of certain species of ichthyoplankton, with larger concentrations of ichthyoplankton being present during and immediately after spawning seasons. Northern anchovy spawn year-round, with peaks from December to May (Love 1991). White croaker also spawn throughout the year, but most spawn from October into April, while Queenfish generally spawn between April and August (Goldberg 1976).

Between 1978 and 1979, much effort was put into characterizing the plankton population at near- and far-field stations near the Harbor Generating Station. This information will be used to characterize zoo- and ichthyoplankton populations in the study area between 1995 and the present.

Critical ichthyoplankton were selected to represent different aspects of the plankton trophic community. The Engraulid species complex (anchovies) are part of an important commercially valuable fish resource. Gobiid species and blennies (*Hypsoblennius* spp.) both represent ubiquitous, endemic bottom fish which are prevalent close to shore in the entire area. Larval sciaenids (queenfish and white croaker) represent the most dominant adult fish in the source water. The diamond turbot represents the carnivorous bottom feeders.

Non-critical species include the Atherinid species complex, *Pleuronichthys* spp., Sciaenid species complex, and unidentified teleosts.

Field Plankton

Between 1978 and 1979, field plankton sampling was performed to characterize diel, temporal and spatial distributional patterns of critical zoo- and ichthyoplankton at near- and far-field source water stations (Figure 4.6; IRC 1981c). An entrainment mortality study was also conducted during the same time period to determine an estimate of the total number of individuals entrained annually for each critical taxa.

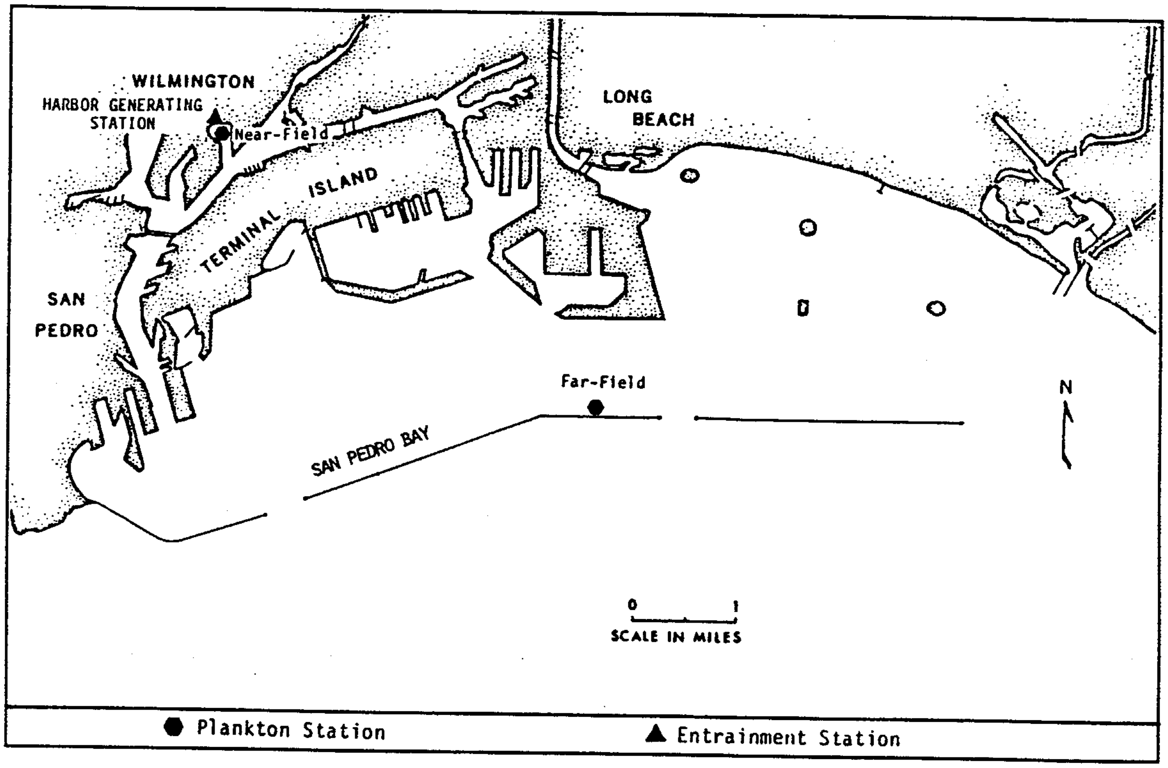

Figure 4.6. Location of near-field and far-field nekton, plankton, and entrainment stations from 1978-1979 (IRC 1981c).

Zooplankton

Seasonality. Most critical zooplankton taxa had higher densities during the spring and summer. Only *Cancer* spp. zoeae showed no consistent pattern, probably because as many as five species of *Cancer*, which have overlapping breeding periods, reside in the study area. The observed seasonal patterns of abundance are consistent with the results of other studies conducted in southern California waters.

Spatial Patterns. Most zooplankton taxa were more abundant at the far-field station. *Cancer* spp. zoeae were more abundant at the near-field station, while *Acanthomysis macropsis* was equally abundant at both stations.

Diel Patterns. All critical zooplankton taxa except *Acartia* spp. were more abundant at night. This pattern may reflect net avoidance during the day, diel shifts in the station of greatest abundance, or movement up into the water column of organisms which reside on the bottom during the day.

Vertical Patterns. Taxa of zooplankton studied were generally most abundant at the mid-depth and bottom strata relative to surface concentrations. *Cancer* spp. zoeae exhibited patterns of upward movement at night. In addition, the mysid *Metamysidopsis elongata* showed no discernible vertical stratification.

Fish Eggs

Seasonality. Fish eggs were usually more abundant during late winter and early spring. However, engraulid eggs were most abundant in spring and summer. Eggs of critical taxa followed seasonality trends related to spawning times of these fish in southern California.

Spatial Patterns. Density values for fish eggs were higher at the far-field station than at the near-field station.

Diel Patterns. Sciaenid eggs were more abundant at night. This may be attributed to night spawning.

Vertical Patterns. No clear distributional pattern was observed for most fish eggs. *Engraulis* eggs, however, were more abundant in surface and mid-depth samples than in bottom collections.

Ichthyoplankton

Seasonality. Fish larvae were generally most abundant during the winter and spring. Blennies and queenfish larvae were most abundant in spring and summer. Engraulid larvae were most abundant in winter through spring, and exhibited a secondary peak period of abundance in the fall.

Spatial Patterns. Gobiid larvae were most abundant at the near-field station. The other ichthyoplankton taxa studied were more abundant at the far-field station.

Diel Patterns. Most larvae were more abundant in night samples. Diel differences in density may be attributed to avoidance of the net by fish larvae during the day.

Vertical Patterns. Fish larvae were most abundant in the mid-depth and bottom regions of the water column. Generally, larger larvae tended to be found in the lower strata.

Nearshore Fish Community

Los Angeles-Long Beach Harbor provides nearshore fish habitat for a variety of fish species. In various biological studies, more than 130 fish species have been found in the Los Angeles-Long Beach Harbor complex, with 60 to 70 species commonly occurring (MEC 1988). The harbor is a "dynamic" environment; dredging and development activities may alter or disrupt areas of the harbor. This, along with seasonal and spatial variability within the harbor, may account for annual variation in species composition and abundance.

White croaker, queenfish, and northern anchovy have historically dominated trawl catches in Los Angeles-Long Beach Harbor (MBC 1994d,e). In eighteen trawl surveys between 1978 and 1994 in the vicinity of the Harbor Generating Station discharge, white croaker and northern anchovy comprised 93% of total fish abundance (MBC 1994d). Listed in Appendix I are fish taken in Los Angeles-Long Beach "inner" harbor areas.

White croaker, queenfish, and northern anchovy are usually found in schools (Love 1991). These fish are commonly taken in nearshore trawl surveys in southern California (MBC 1995b), as well as in embayments (MBC 1995c). White croaker are usually more abundant inshore in summer, and more abundant offshore in winter (Love 1991). Offshore, they are usually found in

3 to 30 m of water (State of California 1987). Queenfish are frequently found occurring in samples with white croaker (Love 1991). These fish school by day and disperse at night to feed (Love 1991), and are most often found at depths of 1.2 to 8.2 m (State of California 1987). Northern anchovy are small, short-lived fish, typically found near the surface (Leet et al. 1992). They move inshore in spring and offshore in the winter (MBC 1987). Northern anchovy are one of the most abundant fishes off California, and an important prey item for many species of fishes, seabirds, and marine mammals (MBC 1987). Two other anchovies, the slough anchovy and deepbody anchovy, have been found in Los Angeles Harbor (MBC 1994d).

Gobies are among the smallest fishes of the sea; most are under three inches long (Goodson 1988). Several species of gobies have been found in Los Angeles Harbor, including bay goby, yellowfin goby, arrow goby, chameleon goby, and cheekspot goby (MBC 1994d).

Perches are common in trawls throughout the Southern California Bight (MBC 1987, 1995b). Since many perches associate with submerged structures (such as outfalls), they are common in impingements at many generating stations in the Bight as well (MBC 1995a). Since 1978, several species of perch have been found in Los Angeles-Long Beach Harbor; they include shiner perch, white seaperch, black perch, rubberlip surfperch, walleye surfperch, barred surfperch, calico surfperch, dwarf surfperch, rainbow surfperch, and pile surfperch (MBC 1994d,e, MEC 1988).

Bottom-dwellers comprise a large majority of the Los Angeles-Long Beach Harbor fish population. California lizardfish, Staghorn sculpin, and plainfin and specklefin midshipman are bottom dwellers common in the harbor and may also be found in the water column. Flatfish include California tonguefish, California halibut, speckled sanddab, spotted turbot, hornyhead turbot, diamond turbot, and fantail sole (MBC 1994d,e). Round stingray and Pacific electric ray are also common on the bottom.

Although kelp bass have been trawled in the harbor, barred sand bass seem to be far more abundant (MEC 1988, MBC 1994d,e). Pacific sardine has been caught infrequently in the harbor, along with Pacific pompano, bay pipefish, chub mackerel, and jack mackerel (MBC 1994d,e).

Critical species chosen for the 1981 316(b) survey were white croaker, queenfish, and shiner perch.

INTERRELATIONSHIP OF PHYSICAL, OCEANOGRAPHIC, AND GENERATING STATION EFFECTS

This section discusses the interrelationship of the marine ecosystem and effects created by the existing cooling water intake system of the Harbor Generating Station.

Source Water Characteristics

The intake of the Harbor Generating Station is located at Slip No. 5, which is situated within a landward extension of Los Angeles Harbor. Movement of water is primarily a function of tidal forces. The volume of water from the entrance of the inner harbor at Reservation Point to the tidal node near the Commodore Heim lift bridge will be considered the reference source water.

Removal or flushing of materials from the inner harbor is largely a function of tidal exchange. During flood tide, oceanic water flows into the harbor and dilutes and mixes with the low-tide water present. Portions of the diluted material are then removed on subsequent flood tides.

In general, current velocities decrease with distance away from the entrance of the inner harbor, meaning that tidal exchange is associated with waters nearer the entrance.

Organisms such as zooplankton are entrained into the system at Slip No. 5 and discharged into the West Basin. Those organisms which may be destroyed are locally reprocessed through the food chain providing the flushing rate is sufficiently small. At greater flushing rates they are processed elsewhere (perhaps San Pedro Bay). Reprocessing is comprised of removal of particles of dead organisms by the direct action of detrital feeders and scavengers. Also, a considerable portion of the reprocessing phase is attributable to the presence of bacteria which mineralize the organic matter by converting it to such chemicals as phosphates, nitrates, carbon dioxide and water. These substances then serve as nutrients for phytoplankton which are the basis of the marine food web.

Not only does the inner harbor receive waste and nutrients but it is also less mixed than the waters of San Pedro Bay. It is evident that the waters located at the intake of the Harbor Generating Station represent a somewhat different habitat than the waters of San Pedro Bay.

Habitat Preference

Distributional strategies and habitat preference of specific taxa determine the extent to which the operational requirements of a generating station can influence source water populations.

Zooplankton

Copepods of the genus *Acartia* are cosmopolitan and inhabit bays, estuaries and coastal waters throughout most of the world. By nature of their distribution, the effect of entrainment on *Acartia* sp. would be diluted over a large area having a longshore configuration within the neritic waters of Southern California.

Of the mysids studied, only *Neomysis kadiakensis* is considered mainly an open-water species. Therefore, entrainment effects upon this organism are likely manifested as small depletions dispersed over a fairly large area, most likely within the Southern California Bight. The other mysids (*Acanthomysis macropsis*, *Metamysidopsis elongata*, and *Mysidopsis* spp.) are considered inshore species. However, entrainment effects of these taxa will be more concentrated within the inner harbor and the shallow, nearshore areas of Los Angeles-Long Beach Harbor.

Zoeae of the *Cancer* spp. crabs are often associated with the open coast or outer bays within the vicinity of rock jetties. However, cancer crabs do inhabit the inner harbor pier areas which provide suitable hard substrata. Entrainment losses of this taxa could affect populations within the inner harbor.

The distributional pattern of fewer *Neotrypaea* spp. zoeae at the near-field station agrees with the HEP (1976) finding of fewer decapod larvae in the inner harbor. This distributional pattern will limit entrainment loss effects to within the confines of the inner harbor and to the shallow inshore areas in close proximity to the inner harbor entrance.

Fish

White croaker, queenfish, and northern anchovy are common throughout the Southern California Bight in both open coast and bay environments. Spawning occurs over a large geographic area, and eggs and larvae become widely dispersed. Extremely high fecundity and high natural mortality rates for larvae are characteristic of these fishes. For these species, reduced recruitment due to entrainment of larvae could affect a large geographic area; however, local magnitude of the impact would be greatly reduced by mixing and dilution.

At the other extreme are larvae of the Gobiid species complex. Adult gobiids are territorial and show no significant movement away from an area of initial settlement. According to Brothers (1975), removal of gobiid larvae from bays by tidal currents represents a major source of mortality. Similarly, blennidae larvae may also suffer high mortality for the same reasons. Based on these features of their life history, it is assumed that for the Gobiid species complex and *Hypsoblennius* spp., recruitment to the adult population relies on larvae spawned nearby. Thus, entrainment losses would be expected to have a more pronounced effect than seen for other open water fish which disperse eggs and larvae and, as adults, range over a large area. For *Hypsoblennius* spp. and Gobiid species complex, reduced recruitment due to egg and larval entrainment would probably be most evident within the bay. Egg and larval production is so high in this area that a small decrease in the number of larvae would not be significant.

Critical taxa such as the diamond turbot and species in the Atherinid species complexes are intermediate between the two extremes of life histories discussed above.

Predation and Generating Station Stresses

The loss of entrained organisms through the Harbor Generating Station cooling water intake system is comprised of two major elements: predation and generating station stresses.

The first element, predation by the biofouling and fish community within the conduit/forebay system leading to the generating station, has been shown at other generating stations to be a major cause of entrainment losses.

The second element is loss of organisms due to various stresses created by the generating station. This is only relevant to those organisms which survived predation during passage through the conduit/forebay system.

IMPACT ASSESSMENT

Since the Harbor Generating Station was tentatively classified by the SWRCB as a potentially low impact generating station, no separate special study on entrainment mortality was done. Instead, estimates of entrainment survival were used from the Haynes Generating Station since the source waters are virtually the same and the plankton community is almost identical. The through-plant survival rates from Haynes Generating Station therefore were applied to Harbor Generating Station's year-long entrainment inventory totals in order to determine the environmental impact.

Total Losses

Zooplankton

Mean daily losses for *Acartia* spp. adults and copepodites are calculated at 0.7%, equivalent to daily entrainment losses of 7.4 X 10^8 adults and 4.11 X 10^8 copepodites (Table 4.1). Entrainment loss ratios for *Acanthomysis macropsis* equaled 1% (5.08 X 10^6 individuals entrained daily), while loss ratios for *Neomysis kadiakensis* equaled 0.4% (6.25 X 10^5 organisms entrained daily). Losses due to entrainment for *Cancer* spp. and *Neotrypaea* spp. zoeae were calculated to be less than 1% (9.79 X 10^6 and 8.15 X 10^5 organisms, respectively). No losses due to entrainment were considered to be significant.

Table 4.1. Zooplankton near-field standing stock estimates, mean daily zooplankton entrainment losses, and percent mean daily near-field loss of standing stock due to entrainment by the Harbor Generating Station (modified from IRC 1981c).

Taxon	Near-Field Standing Stock x 1,000,000	Mean Daily Entrainment Loss x 1,000,000	% Mean Daily Near-Field Loss
Acartia spp. (adults)	110,000	740	0.006727
Acartia spp. (copepodites)	81,800	411	0.005024
Cancer spp. (zoeae)	1340	9.79	0.007306
Callianassa spp. (zoeae)	322	0.815	0.002531
Acanthomysis macropsis	518	5.08	0.009807
Neomysis kadiakensis	143	0.625	0.004371
Metamysidopsis elongata	122	1.17	0.00959

Acartia spp. densities from 19 of 26 field surveys only.

Fish Eggs

Mean daily loss ratio for Sciaenid Species Complex was 0.9% (Table 4.2). This is considered insignificant based on short-time susceptibility and a high natural mortality rate, which is believed to exceed 90% (Ahlstrom 1959). Equivalent adult losses associated with Sciaenid egg mortality are estimated to be 3.53 x 10^3 individuals.

Table 4.2. Ichthyoplankton standing stock estimates, mean daily ichthyoplankton entrainment losses, percent mean daily loss of standing stock, and associated equivalent adult fish losses due to entrainment by the Harbor Generating Station (modified from IRC 1981c).

Taxon	Inner Harbor Standing Stock (Annual Mean)	Mean Daily Entrainment Loss	Mean Daily Loss Ratio	Equivalent Adult Losses
Larvae				
Engraulid Species Complex	15000000	282000	0.0188	1320
Gobiid Species Complex	86400000	1420000	0.016435	8870000
Hypsoblennius spp.	5980000	52800	0.008829	70600
Genyonemus lineatus	18000000	143000	0.007944	4300
Eggs				
Sciaenid Species Complex	114000000	1070000	0.009386	3530

Ichthyoplankton

Engraulid species complex exhibited the highest mean daily loss ratio (1.8%), while other ichthyoplankton ranged from 0.8 to 1.6% (Table 4.2). No losses due to entrainment were considered to be significant. Equivalent adult losses due to entrainment were calculated to be 1.32×10^3 to 8.87×10^6 individuals annually. Based on entrainment rate, source water loss ratios, and adult equivalent loss data, a clearly insignificant impact was demonstrated for all critical ichthyoplankton taxa.

A report developed by the Electric Power Research Institute (EPRI) in 1979 used the following points to argue the statement that likened generating stations to marine predators of plankton: 1) The rapid reproduction potential of plankton permits relatively rapid replacement of individuals killed during entrainment. Because organisms are replaced rapidly, the impact on the ecosystem is negligible. 2) The individuals killed during the entrainment processes are not lost to the system, but are recycled through decomposition processes. 3) Plankton populations are transient, and losses in a given area will be replaced by mixing of the discharged water with unimpacted water masses. 4) Plankton are opportunistic colonizers and highly resilient to perturbations. Extinction or exclusion of such forms due to power plant operation is, therefore, unlikely.

Since 1981, Harbor Generating Station has significantly reduced total cooling water flow. For organisms which are highly susceptible prevailing currents (plankton and eggs), this probably results in reduced entrainment mortality.

Fish

Based upon 34 days of impingement sampling from 1978 through 1979, estimated annual impingement losses for white croaker, queenfish, and shiner perch are shown in Table 4.3. The reduction in the standing stock attributable to impingement from the Harbor Generating Station intake system is less than 1/10 of 1% for queenfish, white croaker, and shiner perch. Since Harbor Generating Station is used as a peaking facility and generates short periods at a time, the intake area lacks an approach velocity field during periods of non-operation. Fish enter the cooling water system during periods when cooling water is not being circulated, and upon initiation of flow, they are impinged.

Table 4.3. Estimated adult fish impingement losses, standing stock estimates of fish in Los Angeles-Long Beach Harbor at 12% and 30% catch efficiencies, and percent of standing stock cropped per day due to impingement by the Harbor Generating Station (modified from IRC 1981c).

Taxon	Impingement Loss (Annual)	(Daily)	Standing Stock @ 12%	@ 30%	% Standing Stock Cropped per Day @ 12%	@ 30%
G. lineatus	47,520	130	18,000,000	7,400,000	0.000722	0.001756757
S. politus	27,337	75	9,700,000	3,900,000	0.000773	0.001923077
C. aggregata	17,455	48	2,400,000	950,000	0.002	0.005052632

Standing stock and natural mortality rates of critical taxa showed no significant effect from operation of the Harbor Generating Station. The principal loss of plankton through grazing transfers energy to a higher trophic level. Source water fish populations displayed normal distributions and reproductive periods.

BEST TECHNOLOGY AVAILABLE

Analysis of data collected during 1978 and 1979 showed Harbor Generating Station was minimizing adverse environmental effects through the use of best technology available. Low impacts from entrapment and impingement demonstrated insignificant losses to marine life in the surrounding waters.

The California State Water Resources Control Board's 316(b) Guidelines (1977) classified cooling water intake systems as low, medium, or high potential impact. Criteria used in classifying impacts included the following: 1) Fish mortality of over 30,000 lbs per year; 2) intake situated in an area of very high value aquatic habitat; 3) intake volume over 1,500 cms; 4) entrainment period long due to conduits; 5) local presence of rare, endangered, or threatened aquatic species; and 6) intake volume relatively low - plant less than 100 MW capacity. Prior to the original 316(b) survey, Harbor Generating Station was classified by the state as a low impact power plant.

Criteria number one was not exceeded during the 1978-1979 survey; the projected impingement loss of approximately 6,234 lbs per year is substantially less. Criteria number two and number five are not applicable to Harbor Generating Station. The inner harbor area is inhabited by species common to southern California coastal waters. The location of the Harbor Generating Station intake structure does not affect rare, endangered, or threatened aquatic species.

Criteria number four (entrainment period long due to conduit lengths) could apply to Harbor Generating Station. Plankton losses in the conduit system have been shown to result mainly from predation and grazing. Criteria number six does not apply to Harbor Generating Station.

For the above reasons, no alternative intake technologies were addressed. Cooling water flow since the original 316(b) survey has declined substantially, most likely leading to lower plant-related entrainment mortalities. Losses of fish at Harbor Generating Station are likely minimized by the intake technology currently used.

CHAPTER 5
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LITERATURE CITED

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APPENDIX A
SCATTERGOOD GENERATING STATION
CIRCULATING WATER FLOW DATA

Appendix A. Scattergood Generating Station circulating water flow data.

Scattergood Generating Station — Units 1, 2 & 3 combined daily flow (mgd)

	Date	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
JAN	1		303.90	224.60	303.90	303.90	415.23	247.68	168.48	247.68	158.85	303.84	168.48	303.84	303.84	382.56
	2		303.90	224.60	300.40	303.90	387.03	247.68	168.48	247.68	112.32	303.84	168.48	329.05	303.84	337.44
	3		303.90	238.80	302.70	305.30	369.63	247.68	168.48	247.68	112.32	303.84	168.48	326.40	396.90	403.71
	4		303.90	264.40	220.80	303.90	365.18	245.57	210.33	247.68	112.32	303.84	168.48	399.83	391.26	410.76
	5		303.90	303.90	212.60	303.90	371.52	193.62	224.64	183.24	112.32	338.61	168.48	400.74	396.90	398.07
	6		303.90	303.90	267.60	303.90	341.21	194.10	224.64	135.36	112.32	303.84	168.48	402.54	399.72	378.33
	7		327.30	303.90	303.90	340.50	341.43	273.77	203.00	135.36	112.32	303.84	168.48	403.25	396.20	374.10
	8		360.00	303.90	303.90	321.50	320.76	266.77	128.70	135.36	112.32	366.84	179.76	349.59	394.08	360.00
	9		360.00	303.90	303.90	339.10	349.01	247.68	12.38	79.24	112.32	354.49	303.84	332.11	365.88	405.12
	10		360.00	303.90	303.90	337.70	363.99	260.57	0.00	0.00	112.32	303.84	280.83	280.11	441.36	405.12
	11		427.60	303.90	168.50	318.70	351.78	267.42	0.00	0.00	112.32	303.84	303.84	338.65	444.66	407.94
	12		427.60	280.50	168.50	303.90	371.52	315.19	0.00	0.00	112.32	303.84	303.84	341.25	396.90	433.32
	13		427.60	247.70	168.50	303.90	368.70	306.79	0.00	0.00	112.32	303.84	384.94	355.32	395.49	361.41
	14		427.60	225.10	168.50	317.30	303.84	247.68	0.00	0.00	115.64	334.86	317.49	322.41	396.90	360.00
	15		386.50	266.40	168.50	315.10	303.84	328.16	0.00	0.00	112.32	296.24	303.84	330.14	382.80	360.00
	16		350.40	303.90	168.50	271.10	303.84	352.47	0.00	0.00	95.17	247.68	303.84	312.05	360.24	453.06
	17		338.70	303.90	168.50	325.00	274.23	383.04	4.68	0.00	112.32	247.68	303.84	303.57	397.28	450.24
	18		295.60	303.90	168.50	352.60	303.84	344.52	114.15	0.00	112.32	257.83	303.84	338.43	427.68	450.24
	19		315.30	303.90	168.50	361.30	274.96	257.72	179.87	0.00	112.32	266.99	303.84	247.68	454.47	435.78
	20		323.90	303.90	303.90	303.90	329.22	181.07	168.48	125.60	112.32	303.84	303.84	321.97	495.36	379.98
	21		371.50	303.90	303.90	303.90	303.84	180.00	168.48	191.52	112.32	303.84	303.84	379.98	495.36	303.84
	22		364.50	303.90	303.90	303.90	303.84	181.66	168.48	191.52	112.32	303.84	278.76	385.62	495.36	324.75
	23		357.40	303.90	289.80	303.90	307.37	234.00	152.57	191.52	76.05	308.07	247.68	313.03	495.36	361.65
	24		315.10	303.90	303.90	303.90	324.99	308.48	168.48	191.52	111.74	308.92	247.68	330.18	495.36	346.14
	25		354.60	303.90	303.90	303.90	317.38	293.48	168.48	216.34	145.20	303.84	274.64	388.16	492.54	324.99
	26		371.50	303.90	303.90	313.70	303.84	319.70	168.48	191.52	236.40	303.84	247.68	382.18	458.70	317.94
	27		334.90	314.40	303.90	310.90	297.78	371.07	168.48	209.34	247.68	303.84	273.57	382.80	495.36	326.40
	28		354.60	303.90	303.90	316.70	211.96	362.32	191.87	300.54	247.68	303.84	299.99	386.07	469.98	308.07
	29		353.20	303.90	303.90	320.10	265.64	240.32	130.34	244.82	208.76	291.74	269.06	381.84	447.42	303.84
	30		303.90	303.90	303.90	303.90	299.85	191.52	159.12	284.41	209.07	247.68	247.68	380.43	441.78	323.58
	31		303.90	303.90	303.90	303.90	235.23	214.52	168.48	284.75	247.68	247.68	247.74	303.84	453.06	320.76
FEB	1		303.90	263.00	303.90	305.73	303.84	337.25	168.48	293.43	247.68	247.68	247.68	182.58	464.34	334.86
	2		303.90	303.90	303.90	303.84	295.65	315.36	176.03	326.88	247.68	187.44	247.68	168.48	472.80	334.86
	3		295.20	303.90	303.90	303.84	342.47	352.00	112.32	360.23	247.68	191.52	288.82	168.48	469.98	334.86
	4		303.90	303.90	303.90	303.84	249.70	352.48	112.32	381.63	247.68	191.63	288.34	168.48	469.98	340.50
	5		303.90	303.90	303.90	303.84	237.57	369.96	112.32	324.27	290.46	221.75	289.84	168.48	446.46	316.53
	6		303.90	303.90	247.70	303.84	177.50	370.63	61.24	363.30	297.03	204.79	281.04	168.48	365.36	347.55
	7		303.90	303.90	247.70	303.84	168.48	247.68	2.29	368.80	270.83	213.35	276.73	168.48	398.16	348.96
	8		292.60	377.50	247.70	303.84	209.37	247.68	56.16	439.09	276.22	315.25	264.32	168.48	334.86	346.14
	9		260.20	303.90	247.70	303.84	303.84	247.68	56.37	399.27	311.36	247.68	261.33	168.48	322.17	346.14
	10		285.20	303.90	247.70	303.84	303.84	203.97	56.16	303.84	267.11	247.68	289.64	168.48	303.84	351.78
	11		319.10	303.90	247.70	303.84	303.84	180.00	56.16	303.84	247.68	301.71	287.08	168.48	289.80	313.71
	12		312.00	303.90	247.70	303.84	281.14	180.00	56.16	303.84	289.05	271.20	268.24	168.48	247.68	320.76
	13		224.60	303.90	247.70	260.36	268.04	206.91	56.16	303.84	289.05	254.34	278.77	168.48	247.68	343.32
	14		201.20	303.90	247.70	218.31	299.16	236.16	56.16	303.84	296.80	247.68	325.30	168.48	325.23	327.81
	15		168.50	317.10	247.70	168.48	247.68	236.16	56.16	261.06	307.44	247.68	306.64	168.48	330.87	309.48
	16		168.50	247.70	247.70	168.48	265.70	236.16	58.87	303.84	264.60	247.68	327.30	168.48	382.80	336.27
	17		168.50	273.50	259.40	168.48	303.84	236.16	56.16	303.84	292.66	223.30	343.49	168.48	361.37	309.48
	18		168.50	303.90	303.90	222.89	290.30	236.16	56.16	303.84	277.06	191.52	301.20	168.48	303.84	348.96
	19		170.80	303.90	303.90	224.64	303.84	246.73	56.16	303.84	293.98	191.52	313.24	168.48	303.84	309.48
	20		168.50	303.90	303.90	224.64	215.01	303.84	56.16	303.84	297.74	227.79	289.75	168.48	303.84	340.50
	21		188.40	315.10	268.80	224.64	168.48	236.16	56.16	303.84	295.94	247.68	261.50	168.48	303.84	334.86
	22		160.30	282.80	247.70	202.81	168.48	242.50	56.16	353.02	292.74	247.68	251.91	168.48	384.21	320.76
	23		132.20	312.90	247.70	224.64	168.48	236.16	81.54	412.86	295.00	247.68	301.06	168.48	343.32	340.50
	24		168.50	303.90	247.70	224.64	168.48	236.16	56.16	411.45	274.66	245.34	247.68	168.48	315.12	340.50
	25		168.50	303.90	247.70	224.64	168.48	236.16	56.16	416.64	236.33	194.44	247.68	168.48	247.68	341.18
	26		168.50	303.90	247.70	224.64	168.48	216.42	56.16	370.79	268.89	247.68	247.68	168.48	271.08	317.94
	27		197.70	303.90	247.70	224.64	168.48	168.48	56.16	439.20	247.69	247.68	247.68	168.48	303.84	347.55
	28		168.50	360.30	247.70	224.64	168.48	168.48	56.16	418.78	287.98	247.68	247.68	168.48	394.08	348.96
	29				247.70				79.56				247.68			

Appendix A. (continued)

Scattergood Generating Station Units 1, 2 & 3 combined daily flow (mgd)

	Date	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
MAR	1		168.50	303.90	316.80	224.64	168.48	168.48	112.32	410.66	296.18	247.68	247.68	168.48	385.51	352.63
	2		168.50	310.90	354.20	224.64	168.48	168.48	112.32	434.18	229.80	247.68	260.82	168.48	341.91	352.63
	3		168.50	360.00	303.90	224.64	168.48	168.48	112.32	439.20	170.55	247.68	288.85	168.48	336.79	353.47
	4		168.50	408.40	303.90	224.64	168.48	168.48	58.50	439.20	179.55	247.68	287.87	137.48	360.00	363.06
	5		168.50	495.30	303.90	224.64	168.48	168.48	67.00	430.74	187.53	247.68	275.32	139.82	360.00	354.60
	6		168.50	434.50	303.90	224.64	168.48	168.48	112.32	439.20	203.04	256.46	247.68	168.48	360.00	357.42
	7		168.50	325.60	303.90	224.64	168.48	168.48	112.32	427.41	198.11	275.95	247.68	168.48	360.00	371.52
	8		168.50	270.00	303.90	224.64	168.48	168.48	112.32	413.82	191.82	247.68	247.68	168.48	360.00	371.52
	9		168.50	275.80	303.90	224.64	168.48	168.48	112.32	439.20	191.42	247.68	247.68	168.48	360.00	371.52
	10		184.90	247.70	303.90	224.64	168.48	300.48	112.32	418.33	187.16	247.68	247.68	168.48	360.00	371.52
	11		224.60	209.90	303.90	224.64	168.48	262.95	112.32	303.84	185.58	247.68	247.68	168.48	360.00	371.52
	12		224.60	247.70	303.90	224.64	168.48	236.16	112.32	348.51	215.65	247.68	247.68	168.48	360.00	350.37
	13		224.60	247.70	303.90	224.64	168.48	236.16	112.32	402.54	227.07	247.68	247.68	168.48	368.46	352.34
	14		224.60	250.10	303.90	224.64	168.48	236.16	112.32	273.19	203.04	248.24	247.68	168.48	360.00	354.60
	15		224.60	209.10	303.90	224.64	228.04	236.16	112.32	387.88	188.74	247.68	247.68	169.65	360.00	360.24
	16		224.60	191.60	303.90	206.69	188.22	236.16	112.32	439.20	191.96	246.98	247.68	168.48	360.00	356.01
	17		224.60	191.60	303.90	168.48	213.60	264.16	112.32	439.20	196.70	247.68	247.68	168.48	360.00	354.60
	18		224.60	191.60	303.90	168.48	303.84	303.84	112.32	439.20	153.49	247.68	247.68	188.56	360.00	350.37
	19		224.60	191.60	303.90	168.48	303.84	303.84	112.32	439.20	188.01	247.68	247.68	224.64	360.00	347.55
	20		224.60	191.60	303.90	168.48	261.60	303.84	112.32	439.20	186.12	247.68	247.68	224.64	391.47	365.13
	21		224.60	191.60	303.90	168.48	269.44	303.84	112.32	416.20	159.30	247.68	247.68	224.64	456.22	355.45
	22		224.60	273.30	303.90	168.48	303.84	377.16	112.32	383.04	180.71	247.68	247.68	224.64	451.65	355.45
	23		224.60	236.70	303.90	168.48	303.84	403.84	123.60	383.04	196.47	247.68	247.68	224.64	457.29	356.01
	24		224.60	191.60	303.90	169.53	338.30	424.19	112.32	383.04	203.04	194.69	247.68	224.64	457.74	354.60
	25		224.60	253.60	303.90	193.82	324.71	402.54	112.32	354.77	178.36	168.48	247.68	149.22	452.16	351.78
	26		224.60	191.60	303.90	224.64	310.92	354.21	112.32	435.53	188.83	168.48	247.20	112.32	418.71	315.12
	27		224.60	191.60	303.90	199.67	315.55	303.84	112.32	416.19	187.73	168.48	247.68	112.32	364.68	353.19
	28		224.60	259.20	303.90	224.64	332.04	382.04	112.32	439.20	203.04	168.48	291.67	112.32	445.73	351.78
	29		220.00	262.10	303.90	224.64	303.84	340.67	112.32	412.69	195.29	160.01	289.75	153.43	446.97	354.60
	30		168.50	264.90	303.90	224.64	288.63	393.80	112.32	383.04	164.04	112.32	295.96	168.48	440.82	371.52
	31		168.50	261.10	303.90	224.64	247.68	405.64	137.70	356.25	183.94	112.32	292.86	168.48	444.54	371.52
APR	1		154.40	372.40	303.90	224.64	247.68	419:46	180.00	356.81	158.12	247.23	287.72	168.48	309.48	308.92
	2		112.30	360.00	303.90	224.64	247.68	409.59	180.00	351.49	75.21	247.68	247.68	168.48	303.84	303.84
	3		112.30	224.60	303.90	224.64	296.82	415.69	180.00	412.41	67.68	247.68	288.80	168.48	284.95	303.84
	4		112.30	317.70	303.90	224.64	328.15	407.23	180.00	439.20	12.69	247.68	258.40	168.48	348.81	303.84
	5		112.30	307.40	303.90	224.64	303.84	417.77	112.32	439.20	10.94	247.68	237.36	170.16	351.99	303.84
	6		112.30	303.90	303.90	240.43	303.84	406.77	144.75	382.12	67.68	247.68	285.27	168.48	269.00	303.84
	7		112.30	257.30	303.90	292.32	303.84	411.38	180.00	439.20	67.68	247.68	282.70	168.48	310.85	308.99
	8		112.30	227.40	303.90	292.32	336.98	395.26	180.00	392.22	106.48	290.43	285.55	215.75	351.65	360.00
	9		112.30	247.70	303.90	247.20	339.23	303.84	180.00	380.66	220.25	247.68	289.05	206.51	359.54	287.46
	10		112.30	247.70	303.90	289.50	338.24	365.88	180.00	413.26	308.28	247.68	292.32	168.48	364.24	247.68
	11		112.30	247.70	303.90	360.00	344.73	365.88	180.00	414.10	308.44	282.94	256.85	168.48	420.90	247.68
	12		112.30	247.70	303.90	352.98	303.84	424.41	247.68	374.76	301.03	303.84	266.49	168.48	400.43	247.68
	13		112.30	247.70	303.90	303.84	303.84	341.20	187.22	418.22	260.01	303.84	295.62	168.48	435.68	247.68
	14		112.30	244.80	303.90	327.24	341.57	314.61	247.68	415.79	171.09	303.84	293.03	168.48	393.46	247.68
	15		112.30	247.70	319.10	303.84	347.24	348.70	191.52	331.59	135.36	303.65	295.25	168.48	416.25	247.68
	16		112.30	247.70	360.00	305.25	342.14	368.84	191.52	365.82	162.01	303.84	297.37	168.48	482.81	247.68
	17		112.30	247.70	353.00	348.11	351.30	356.76	201.86	409.14	184.34	303.84	295.85	168.48	495.36	247.68
	18		100.60	247.70	303.90	314.27	340.78	371.52	247.68	412.02	184.48	303.84	289.98	168.48	495.36	247.68
	19		0.00	247.70	303.90	303.84	347.32	354.24	247.68	439.20	182.37	248.85	274.75	168.48	481.26	247.68
	20		0.00	247.70	272.30	254.70	319.04	315.36	247.68	439.12	295.57	247.68	300.08	151.70	449.68	247.68
	21		0.00	247.70	247.70	247.68	348.20	315.36	247.68	439.20	296.24	247.68	298.52	138.48	412.56	247.68
	22		70.20	247.70	247.70	247.68	323.10	312.40	247.68	401.02	251.21	247.68	271.65	153.27	482.35	247.68
	23		112.30	247.70	196.20	247.68	158.51	315.36	180.00	377.55	293.79	247.68	296.55	112.32	465.58	247.68
	24		112.30	247.70	191.60	247.68	112.32	308.07	180.00	387.03	294.84	247.68	318.69	112.32	483.91	247.68
	25		112.30	247.70	191.60	295.07	70.97	304.22	212.20	388.89	291.86	247.68	329.60	112.32	448.13	247.68
	26		112.30	247.70	191.60	303.84	0.00	315.36	247.68	401.69	317.83	247.68	319.59	131.04	412.82	247.68
	27		112.30	247.70	191.60	336.27	9.36	306.43	247.68	431.70	336.60	247.68	327.60	168.48	365.85	247.68
	28		112.30	247.70	191.60	303.84	56.16	315.36	247.68	388.44	288.20	247.68	330.42	145.48	435.56	247.68
	29		112.30	247.70	191.60	342.47	80.15	315.36	247.68	318.90	254.25	247.68	329.91	136.12	409.82	247.68
	30		146.30	247.70	44.60	343.32	56.16	315.36	247.68	404.91	292.09	247.68	292.97	168.48	338.81	247.68

Appendix A. (continued)

Scattergood Generating Station — Units 1, 2 & 3 combined daily flow (mgd)

	Date	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
MAY	1		168.50	247.70	174.00	303.84	56.16	288.71	247.68	382.63	296.07	247.68	247.68	168.48	361.65	257.55
	2		168.50	247.70	270.00	339.60	124.66	282.31	247.68	293.61	296.55	238.13	288.74	188.77	399.65	247.68
	3		168.50	247.70	285.20	348.54	191.52	294.01	122.26	377.58	296.55	202.62	289.53	224.64	371.52	254.17
	4		88.90	247.70	257.70	336.41	191.52	285.75	182.82	387.59	296.55	247.68	318.57	224.64	405.98	255.01
	5		56.20	247.70	257.70	319.91	191.52	307.46	172.10	405.53	271.93	247.68	279.56	224.64	400.00	247.68
	6		18.70	247.70	257.70	332.55	191.52	277.15	112.32	410.04	269.76	303.42	312.99	224.64	363.06	271.09
	7		51.50	247.70	257.70	334.44	191.52	303.52	112.32	388.72	272.98	303.84	328.56	224.64	303.78	256.99
	8		112.30	247.70	257.70	317.94	191.52	303.15	112.32	407.22	338.59	318.28	330.59	224.64	268.87	271.65
	9		112.30	247.70	257.70	303.84	191.52	299.06	112.32	404.63	352.71	346.08	335.55	224.64	359.94	247.68
	10		85.40	247.70	257.70	303.84	191.52	293.65	112.32	305.08	359.76	303.84	275.88	175.69	338.88	247.68
	11		56.20	247.70	257.70	312.78	191.52	309.80	112.32	339.02	358.69	303.84	304.76	168.48	303.78	236.40
	12		105.30	247.70	257.70	306.86	191.52	315.36	112.32	326.47	334.49	306.18	323.82	168.48	273.36	180.00
	13		112.30	247.70	257.70	338.16	191.52	301.74	112.32	319.05	303.84	304.01	327.09	220.85	267.10	180.00
	14		112.30	247.70	283.00	343.97	191.52	298.58	112.32	303.84	352.26	303.84	321.56	202.20	251.13	180.00
	15		112.30	247.70	257.70	360.00	199.98	343.14	112.32	303.84	354.60	303.84	339.50	18.49	247.62	202.56
	16		112.30	247.70	257.70	361.41	191.52	394.36	112.32	303.84	355.78	303.84	345.96	0.00	269.50	247.68
	17		112.30	247.70	257.70	360.00	207.03	329.21	112.32	303.84	352.96	303.84	334.86	0.00	305.53	247.68
	18		180.00	247.70	257.70	309.64	191.52	360.00	112.32	303.84	358.55	303.84	356.46	0.00	280.58	247.68
	19		247.70	247.70	268.90	285.12	191.52	360.00	112.32	368.70	345.66	303.84	346.42	0.00	255.20	247.68
	20		247.70	247.70	266.10	247.68	191.52	360.00	138.64	306.83	341.83	303.95	345.32	0.00	303.84	247.68
	21		247.70	247.70	257.70	247.68	191.52	360.00	244.86	303.84	371.84	303.84	356.91	0.00	303.84	247.68
	22		247.70	247.70	297.10	247.68	191.52	360.00	247.68	342.47	358.99	303.84	347.10	0.00	312.30	247.68
	23		247.70	247.70	297.10	247.68	191.52	344.49	247.68	303.84	352.42	303.84	303.84	112.32	351.41	247.68
	24		243.40	247.70	295.70	250.27	191.52	360.00	247.68	303.84	408.87	303.84	303.84	137.31	360.00	247.68
	25		346.40	247.70	285.90	247.68	191.52	360.00	247.68	303.84	404.27	303.84	322.40	168.48	360.00	247.68
	26		261.80	290.00	257.70	247.68	191.52	332.93	243.73	303.84	360.00	303.84	324.73	168.48	360.00	247.68
	27		247.70	309.70	257.70	247.68	210.05	224.64	247.68	303.84	360.00	303.84	350.37	168.48	360.00	247.68
	28		247.70	247.70	230.20	247.68	249.09	224.64	247.68	303.84	342.45	303.84	331.59	217.13	303.84	247.68
	29		247.70	247.70	278.80	247.68	282.37	224.64	247.68	303.84	303.84	303.84	354.60	303.84	303.84	247.68
	30		247.70	247.70	288.60	247.68	281.29	224.64	247.68	303.84	342.05	303.84	362.95	303.84	360.00	247.68
	31		247.70	247.70	281.50	247.68	247.68	224.64	247.68	303.84	323.81	303.84	367.97	303.84	360.00	247.68
JUN	1		247.70	247.70	270.20	247.68	255.21	224.64	247.68	402.54	338.58	303.84	381.50	295.38	303.84	247.68
	2		247.70	247.70	247.70	247.68	297.03	266.94	247.68	412.30	311.74	303.84	390.98	236.16	303.84	262.63
	3		247.70	247.70	247.70	247.68	288.37	360.00	247.68	305.70	334.01	303.84	397.01	185.85	303.84	247.68
	4		247.70	247.70	247.70	247.68	333.96	403.71	247.68	328.26	332.04	303.84	379.02	236.16	305.34	247.68
	5		247.70	247.70	247.70	283.95	299.78	412.34	247.68	375.19	314.19	303.84	352.06	255.20	303.84	247.68
	6		264.60	247.70	247.70	323.56	302.04	370.91	247.68	356.29	292.14	303.84	318.90	273.53	303.84	256.14
	7		312.50	273.50	247.70	381.15	341.52	360.00	247.68	328.94	293.73	303.84	357.42	266.00	303.84	247.68
	8		306.90	296.90	258.90	370.43	300.07	383.12	247.68	362.10	286.93	257.34	337.40	303.84	303.84	273.62
	9		247.70	320.80	247.70	360.00	302.55	391.76	247.68	404.68	247.68	236.16	346.37	303.84	303.84	247.68
	10		258.90	303.90	247.70	389.05	298.09	331.42	247.68	426.90	247.68	236.16	334.86	303.84	303.84	247.68
	11		306.90	351.80	247.70	385.38	300.74	367.06	247.68	304.07	281.52	236.16	318.05	303.84	303.84	236.40
	12		318.20	303.90	246.20	389.05	304.07	335.62	247.68	371.35	267.56	236.16	327.36	303.84	303.84	180.00
	13		247.70	301.50	273.00	360.00	312.11	250.97	245.34	387.55	247.68	273.86	394.53	303.84	303.84	180.00
	14		247.70	312.30	264.60	366.77	271.02	360.24	247.68	247.68	247.68	303.84	304.12	303.84	303.84	180.00
	15		247.70	326.40	253.30	364.51	262.49	353.56	247.68	338.52	247.68	303.84	312.75	303.84	303.84	202.56
	16		309.70	343.30	247.70	360.00	271.37	338.16	247.68	399.47	247.68	303.84	347.10	312.30	303.84	247.68
	17		364.80	349.00	247.70	360.00	292.32	334.38	247.68	428.20	247.68	303.84	352.51	369.10	304.32	247.68
	18		318.20	303.90	340.50	360.00	295.25	346.93	247.68	439.20	247.74	303.84	350.37	315.64	322.17	247.68
	19		247.70	303.90	275.80	360.00	303.80	329.93	247.68	439.09	247.82	303.84	348.96	314.40	327.33	247.68
	20		247.70	303.90	279.50	351.58	320.99	243.21	179.83	390.30	280.82	303.84	303.84	247.68	377.24	218.92
	21		247.70	310.90	305.70	347.00	315.40	303.84	247.68	390.30	211.59	303.84	311.62	247.68	384.94	247.68
	22		247.70	308.60	303.90	395.53	303.84	343.12	247.68	393.18	191.52	303.84	377.61	247.68	387.48	233.58
	23		247.70	306.70	268.60	381.43	303.84	353.42	247.68	383.08	213.46	303.84	380.94	247.68	433.65	191.84
	24		247.70	303.90	303.90	362.82	303.84	352.49	247.68	388.72	195.89	303.84	374.73	333.94	451.37	247.68
	25		247.70	303.90	334.90	360.00	337.06	352.49	247.68	385.90	243.88	303.84	363.41	339.78	427.37	264.88
	26		247.70	303.90	340.50	367.33	326.88	301.73	224.89	393.69	391.76	303.84	356.01	319.03	396.52	284.34
	27		247.70	287.50	337.70	282.17	337.20	325.72	245.45	396.51	408.87	303.84	353.92	298.05	453.26	298.44
	28		247.70	247.70	323.60	272.30	247.44	339.68	146.48	399.16	388.26	303.84	321.21	332.00	447.70	287.16
	29		247.70	247.70	326.40	360.00	265.54	372.84	135.36	396.62	360.00	303.84	353.47	364.55	448.32	287.16
	30		300.40	310.10	303.90	357.66	338.53	368.35	135.36	381.00	360.00	303.84	327.64	385.51	419.05	287.16

Appendix A. (continued)

Scattergood Generating Station — Units 1, 2 & 3 combined daily flow (mgd)

	Date	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
JUL	1	444.00	168.50	332.10	303.90	342.45	348.68	409.21	149.40	333.45	360.00	303.84	359.73	349.13	440.74	268.83
	2	362.70	149.80	329.20	337.70	378.33	351.86	362.12	227.74	358.83	360.00	359.93	341.46	325.72	414.99	270.24
	3	402.00	112.30	306.70	349.80	427.68	340.64	358.42	247.68	383.70	360.00	360.00	363.17	210.78	360.00	228.50
	4	437.80	112.30	303.90	360.00	406.30	303.84	360.00	261.72	380.15	360.00	360.00	303.84	303.84	360.00	247.68
	5	437.80	112.30	303.90	372.70	361.41	328.04	375.51	303.84	353.44	360.00	360.00	331.31	303.84	360.00	189.87
	6	457.00	112.30	303.90	379.70	407.94	311.68	367.49	269.09	387.99	363.69	360.00	381.50	344.25	369.02	244.86
	7	441.70	112.30	327.80	389.60	392.77	315.49	344.81	250.02	339.00	360.00	358.83	354.15	388.44	421.20	292.80
	8	450.20	152.10	349.60	386.80	413.24	321.61	333.68	303.84	383.29	360.00	303.84	387.48	426.06	378.12	227.94
	9	449.60	191.10	383.90	398.00	420.40	342.70	337.82	303.84	414.48	360.00	303.84	400.28	370.39	389.40	315.36
	10	443.40	261.60	360.00	399.40	395.81	328.04	349.44	303.84	415.07	399.48	303.84	427.47	339.09	327.67	315.36
	11	425.90	303.90	403.70	402.30	427.68	337.26	343.09	303.84	437.78	409.12	303.84	371.52	303.84	381.39	315.36
	12	392.70	357.40	385.30	398.00	406.62	339.09	336.98	303.84	431.23	412.03	303.84	323.58	379.87	388.44	315.36
	13	439.50	340.70	403.70	402.30	325.19	345.35	353.81	360.00	436.37	438.25	329.22	384.60	380.71	381.84	315.36
	14	444.00	321.30	409.30	396.60	371.52	333.45	353.14	360.00	434.93	436.14	303.84	384.83	370.96	303.84	273.06
	15	433.30	269.00	367.10	410.70	416.96	335.28	408.42	318.41	360.00	360.00	358.15	390.58	392.50	303.84	292.80
	16	423.70	247.70	258.70	407.90	426.27	325.92	329.07	321.56	360.00	358.87	383.08	390.81	303.84	303.84	315.36
	17	238.00	247.70	260.20	419.20	403.71	328.43	349.67	360.00	358.11	451.48	385.62	431.18	303.84	306.18	315.36
	18	224.60	247.70	295.10	416.40	404.42	331.70	342.98	360.00	360.00	419.27	335.31	408.90	303.84	316.02	337.92
	19	224.60	372.70	330.70	405.10	352.00	342.62	347.07	360.00	360.00	454.92	357.42	360.00	327.81	360.24	405.22
	20	270.90	394.10	343.30	392.40	360.00	331.90	350.45	360.00	360.00	401.05	307.62	345.90	331.76	388.44	416.64
	21	392.70	388.50	340.50	360.00	412.00	341.40	353.11	360.00	360.00	397.17	303.84	264.12	369.83	391.26	401.13
	22	394.90	394.10	325.60	360.00	349.05	343.66	352.82	360.00	360.00	392.63	357.25	224.64	383.76	385.62	439.20
	23	359.10	433.60	391.00	385.30	346.93	324.23	353.67	360.00	360.00	401.79	375.99	224.64	361.93	342.19	441.54
	24	360.80	357.40	360.00	398.00	356.92	323.50	346.28	360.00	377.43	380.53	379.53	224.64	372.93	358.38	495.36
	25	345.90	303.90	374.10	391.00	308.20	322.45	326.67	360.00	394.00	438.79	375.30	257.52	314.16	396.90	495.36
	26	336.00	391.30	360.00	393.80	289.56	303.84	338.86	360.00	406.53	391.16	367.29	367.75	375.19	411.00	472.80
	27	320.80	380.00	360.00	393.80	402.59	303.84	350.23	360.00	403.06	420.35	343.21	439.41	373.32	416.64	391.02
	28	341.60	388.50	323.30	381.10	402.07	327.33	404.05	360.00	398.63	424.86	303.84	430.27	375.64	407.22	495.36
	29	319.10	382.80	303.90	360.00	360.00	323.02	408.73	360.00	378.56	421.08	419.34	373.35	380.43	391.26	495.36
	30	362.60	396.90	306.70	399.40	362.20	327.39	379.03	364.68	360.00	436.14	425.51	363.99	389.57	387.62	438.96
	31	292.20	303.90	334.40	396.60	408.31	303.84	322.27	360.00	381.15	431.74	372.91	389.57	384.38	379.98	383.04
AUG	1	247.70	303.90	316.60	393.80	423.73	342.23	314.28	360.00	395.96	444.71	384.66	382.97	382.80	388.44	495.36
	2	276.40	291.00	303.90	393.80	427.68	258.66	360.00	360.00	390.09	441.10	361.20	367.74	394.08	384.21	495.36
	3	312.00	257.70	303.90	393.80	415.27	290.22	360.00	307.54	383.69	360.00	303.84	389.85	399.72	385.62	495.36
	4	331.10	257.70	303.90	360.00	402.58	341.63	360.00	340.22	437.10	378.61	303.84	388.72	399.72	388.44	495.36
	5	329.40	257.70	303.90	360.00	398.63	327.44	245.79	303.84	425.82	360.00	292.56	379.13	399.72	396.90	495.36
	6	410.80	271.10	205.20	393.80	404.42	339.36	360.00	357.42	390.63	318.18	303.84	387.48	399.72	383.25	495.36
	7	495.30	303.90	310.80	391.00	403.43	284.81	360.00	461.83	429.26	321.93	349.79	392.95	348.96	368.70	495.36
	8	424.30	303.90	360.00	402.30	404.42	303.84	360.00	399.48	392.63	420.91	355.05	379.81	360.24	392.95	495.36
	9	324.40	303.90	360.00	379.70	400.33	261.06	360.00	443.19	396.86	442.71	366.44	376.14	388.44	408.60	433.32
	10	334.90	282.70	350.70	360.00	400.04	236.16	360.00	441.78	395.02	444.88	303.84	390.13	207.96	375.43	426.27
	11	387.60	236.20	250.30	371.20	394.26	304.80	360.00	438.50	398.55	439.92	438.75	366.17	303.84	348.07	427.68
	12	343.10	236.20	303.90	360.00	379.88	345.44	360.00	397.86	397.79	429.32	383.76	417.37	303.84	343.56	395.74
	13	308.50	204.60	303.90	388.20	321.86	341.35	360.00	369.38	373.79	403.37	383.25	430.09	303.84	383.04	388.60
	14	287.10	180.00	303.90	360.00	360.00	337.45	360.00	303.84	345.91	392.29	354.60	460.56	303.84	363.30	401.13
	15	237.50	180.00	303.90	388.20	360.00	344.53	360.00	352.06	344.96	426.75	362.61	446.69	303.84	340.74	395.77
	16	275.30	180.00	339.00	396.60	400.89	303.84	360.00	378.01	338.61	440.20	340.89	495.36	309.48	342.15	303.84
	17	288.00	180.00	406.10	396.60	382.28	330.97	360.00	394.93	344.39	436.59	354.60	495.36	303.84	338.48	303.84
	18	273.30	180.00	406.10	379.70	360.00	387.89	360.00	384.66	333.68	416.40	323.58	460.56	303.84	336.51	379.98
	19	277.70	180.00	339.00	360.00	399.76	397.42	360.00	389.74	303.84	306.18	387.42	451.20	404.28	332.28	439.20
	20	247.70	180.00	303.90	391.00	402.30	389.75	360.00	376.20	303.84	322.30	384.21	456.33	313.20	358.83	439.20
	21	247.70	180.00	303.90	402.30	362.54	397.84	299.37	303.84	334.35	320.27	381.11	430.97	303.84	357.42	439.20
	22	295.80	184.70	303.90	382.50	360.00	384.68	286.68	384.21	341.91	322.92	385.62	348.79	303.84	369.66	439.20
	23	360.00	163.10	303.90	379.70	362.82	360.00	360.00	387.59	303.84	270.97	359.79	343.77	278.46	386.93	469.62
	24	399.40	180.00	303.90	396.60	402.86	360.00	360.00	389.40	303.84	247.68	375.71	380.54	303.84	380.43	439.20
	25	397.70	180.00	303.90	393.80	427.68	392.99	360.00	391.74	303.84	258.79	303.84	379.13	303.84	397.13	383.04
	26	407.90	180.00	303.90	402.30	408.65	396.32	360.00	382.92	303.84	303.84	380.88	375.75	309.48	388.89	383.04
	27	427.60	180.00	303.90	393.80	416.12	350.42	360.00	375.30	303.84	303.84	370.56	379.98	303.84	389.34	357.66
	28	426.50	180.00	303.90	402.30	427.68	327.95	360.00	373.10	303.84	274.46	380.43	397.10	303.84	382.77	383.04
	29	382.00	180.00	339.00	405.10	409.35	336.78	360.00	398.93	303.84	355.67	377.61	388.46	255.90	382.80	390.06
	30	360.00	180.00	360.00	405.10	427.68	368.42	360.00	428.64	296.63	360.02	378.18	303.84	236.16	385.20	439.20
	31	393.80	180.00	360.00	399.40	410.76	355.59	359.30	375.01	289.80	343.94	345.43	371.07	236.16	368.70	439.20

Appendix A. (continued)

Scattergood Generating Station   Units 1, 2 & 3 combined daily flow (mgd)

	Date	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
SEP	1	401.40	214.00	340.20	385.30	415.70	303.84	316.29	345.00	303.84	326.54	354.60	343.80	236.16	364.02	439.20
	2	374.50	236.20	433.30	382.50	407.24	303.84	360.00	374.00	303.84	303.84	347.04	383.76	236.16	379.98	439.20
	3	347.60	236.20	360.00	379.70	405.66	305.73	290.25	387.00	314.50	321.46	372.53	382.40	236.16	375.30	452.77
	4	359.70	236.20	360.00	405.10	406.05	318.45	224.64	418.00	322.51	365.18	370.06	381.39	236.16	337.68	439.20
	5	335.70	285.30	360.00	405.10	360.00	335.76	188.76	440.00	350.88	383.96	371.07	365.43	236.16	369.86	439.20
	6	320.20	292.30	360.00	399.40	360.00	303.84	222.30	437.00	353.19	407.27	381.22	339.09	236.16	347.78	439.20
	7	333.20	292.30	360.00	396.60	384.68	316.05	224.64	406.00	346.14	415.99	339.54	353.26	236.16	386.18	439.20
	8	345.30	292.30	382.50	396.60	345.70	303.84	224.64	360.00	344.73	395.58	304.07	382.63	236.16	388.44	399.42
	9	349.80	292.30	360.00	402.30	409.35	324.06	224.64	304.00	344.25	395.42	362.67	374.91	236.16	388.44	351.78
	10	345.90	290.00	374.10	405.10	403.94	303.84	224.64	304.00	336.13	443.08	383.53	332.83	236.16	346.85	439.20
	11	355.20	199.70	360.00	385.30	407.43	303.84	224.64	304.00	391.20	440.65	377.61	338.05	272.82	303.84	400.59
	12	345.00	339.00	402.30	402.30	406.53	303.84	168.48	304.00	353.19	430.15	343.28	353.54	320.76	377.16	441.28
	13	333.50	247.70	402.30	402.30	411.38	303.84	168.48	304.00	355.16	388.25	368.98	327.81	408.18	343.32	439.20
	14	303.90	247.70	385.30	399.40	405.49	303.84	168.48	388.00	371.52	400.68	349.41	382.34	365.88	377.16	433.87
	15	257.60	252.40	360.00	360.00	423.31	303.84	168.48	366.00	346.14	289.09	319.35	398.36	326.40	429.12	413.19
	16	236.20	303.90	360.00	385.30	383.71	303.84	168.48	336.00	303.84	277.05	348.25	396.73	378.57	399.32	363.06
	17	236.20	303.90	360.00	405.10	382.97	303.84	250.73	337.00	303.84	236.16	390.30	400.68	250.26	433.77	303.84
	18	236.20	303.90	360.00	402.30	351.55	303.84	303.84	304.00	303.84	227.98	389.99	424.90	303.84	391.13	325.74
	19	236.20	303.90	360.00	402.30	350.23	237.57	219.24	346.00	303.84	303.84	393.12	424.47	303.84	446.46	317.41
	20	224.60	303.90	290.90	396.60	351.30	235.93	168.48	313.00	303.84	303.84	373.50	311.69	333.45	445.53	365.88
	21	292.30	303.90	224.60	396.60	371.52	236.16	168.48	305.00	303.84	304.46	339.57	330.05	340.50	448.35	377.16
	22	292.30	303.90	175.50	312.00	345.63	333.03	168.48	349.00	303.84	303.84	335.56	345.42	313.71	469.75	352.91
	23	292.30	303.90	224.60	360.00	362.36	331.67	168.48	352.00	303.84	303.84	395.72	345.65	374.34	447.42	354.60
	24	292.30	303.90	168.50	382.50	365.88	347.16	168.48	304.00	303.84	303.84	475.30	305.21	391.26	360.00	373.86
	25	292.30	318.00	168.50	385.30	371.52	350.37	168.48	304.00	278.46	307.51	350.98	336.96	374.26	320.52	360.24
	26	326.10	289.80	128.70	391.00	371.52	344.11	168.48	304.00	236.16	358.06	353.97	320.04	368.70	224.64	340.50
	27	360.00	247.70	156.50	388.20	350.60	342.81	168.48	306.00	237.56	360.00	345.43	312.99	387.03	224.64	378.32
	28	364.30	247.70	155.80	393.80	344.59	329.57	168.48	356.00	292.32	360.00	335.34	332.28	391.26	224.64	303.84
	29	303.90	247.70	168.50	388.20	303.84	286.40	168.48	347.00	292.32	313.20	330.71	321.25	388.44	224.64	346.14
	30	335.70	251.90	168.50	360.00	346.48	286.60	168.48	353.00	292.32	303.84	345.77	326.19	388.44	224.64	377.16
OCT	1	357.40	281.50	168.50	402.30	336.81	344.03	170.63	292.39	292.32	303.84	353.05	325.23	389.85	224.64	375.03
	2	327.80	250.50	168.50	396.60	293.69	340.47	224.64	278.94	288.81	380.74	404.70	326.25	301.02	224.64	382.80
	3	317.70	247.70	168.50	362.80	371.52	346.47	224.64	311.08	236.16	303.84	401.71	311.58	350.37	224.64	388.44
	4	334.30	222.70	168.50	256.10	371.52	343.32	224.64	292.40	236.16	289.12	343.09	264.60	387.03	224.64	377.16
	5	353.80	258.90	205.90	250.60	371.52	343.56	224.64	256.01	236.16	395.94	337.40	331.43	388.44	224.64	357.42
	6	371.50	213.90	224.60	228.70	358.27	336.39	222.58	279.11	236.16	378.40	331.81	334.14	381.39	224.64	315.12
	7	371.00	247.70	224.60	306.40	371.52	354.51	168.48	324.79	236.16	365.88	347.32	334.14	382.80	224.64	303.84
	8	353.50	223.40	224.60	393.80	329.22	354.55	168.48	304.80	244.35	420.30	348.25	333.69	363.06	168.48	303.84
	9	371.50	244.80	224.60	396.60	371.52	352.72	168.48	308.52	292.32	431.74	348.73	335.21	361.65	168.48	312.30
	10	371.50	247.70	224.60	406.50	371.52	354.51	168.48	360.00	292.32	433.21	350.37	328.05	322.17	168.48	348.96
	11	371.50	284.30	224.60	398.00	360.24	355.31	168.48	328.56	289.98	379.53	348.25	316.77	377.16	157.95	343.32
	12	371.50	292.80	224.60	389.60	371.52	353.99	168.48	360.00	236.16	303.84	349.19	333.63	395.49	112.32	388.44
	13	371.50	344.80	224.60	360.00	371.52	347.79	168.48	360.00	236.16	355.62	339.09	328.50	377.16	112.32	439.20
	14	383.20	339.10	224.60	365.60	367.57	355.12	168.48	360.00	236.16	316.08	343.07	330.42	387.03	112.32	439.20
	15	427.60	337.70	224.60	340.00	358.83	355.31	168.48	360.00	180.00	327.42	340.50	332.73	399.72	112.32	439.20
	16	427.60	309.50	224.60	386.80	360.00	359.09	168.48	360.00	180.00	387.99	341.49	292.80	392.67	112.32	457.92
	17	427.60	311.40	224.60	405.10	360.00	299.85	168.48	360.00	180.00	384.10	347.32	289.59	324.99	112.32	439.20
	18	427.60	360.00	224.60	392.40	360.00	299.85	168.48	360.00	180.00	384.10	349.67	264.88	388.44	162.63	429.33
	19	427.60	360.00	224.60	400.90	360.00	300.32	168.48	360.00	180.00	404.34	345.10	333.41	388.44	168.48	439.20
	20	427.60	360.00	224.60	360.00	360.00	315.36	168.48	313.10	180.00	406.77	337.57	336.68	377.16	168.48	412.69
	21	427.60	360.00	292.30	360.00	315.36	315.36	168.48	303.84	180.00	307.11	374.79	336.06	387.03	168.48	303.84
	22	427.60	413.50	338.80	360.00	289.47	311.07	168.48	303.84	179.77	303.84	391.94	328.73	392.67	168.48	303.84
	23	427.60	309.20	292.30	360.00	306.20	293.46	168.48	303.84	112.32	303.85	385.85	198.33	372.93	168.48	365.88
	24	427.60	360.00	360.00	360.00	309.72	340.22	168.48	303.84	125.94	320.34	344.98	247.68	357.42	168.48	374.34
	25	427.60	309.20	360.00	360.00	315.36	344.73	168.48	303.84	180.00	334.07	349.52	282.08	392.67	168.48	306.18
	26	427.60	360.00	360.00	360.00	315.36	311.98	164.57	303.84	180.00	356.49	347.32	328.05	395.49	168.48	374.34
	27	392.50	360.00	436.10	360.00	294.44	293.08	194.22	303.84	180.00	318.28	344.17	247.68	389.85	191.88	389.34
	28	315.30	360.00	458.70	360.00	288.43	277.99	224.64	317.88	180.00	316.50	355.53	247.68	385.62	168.48	391.20
	29	315.30	360.00	360.00	352.90	247.68	290.64	224.64	360.00	187.50	303.84	360.66	247.68	396.90	168.48	371.52
	30	315.30	360.00	341.30	388.20	290.32	312.41	217.04	360.00	180.00	303.84	390.08	238.26	399.72	168.48	394.08
	31	315.30	375.00	296.10	338.80	112.32	371.52	123.62	360.00	180.00	303.84	355.81	340.95	389.85	149.36	399.72

Appendix A. (continued)

Scattergood Generating Station Units 1, 2 & 3 combined daily flow (mgd)

	Date	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NOV	1	401.90	360.00	320.80	360.00	352.87	371.52	168.48	360.00	180.00	303.84	302.06	383.25	441.84	168.48	422.28
	2	371.50	303.90	295.40	399.40	371.52	343.09	168.48	360.00	180.00	303.84	171.07	405.36	449.97	168.48	399.72
	3	323.60	303.90	267.20	357.30	371.52	301.28	168.48	360.00	180.00	303.84	168.48	397.75	474.49	168.48	380.51
	4	303.90	303.90	305.30	319.40	323.15	281.44	168.48	360.00	180.00	340.50	216.26	395.88	474.49	168.48	388.44
	5	303.90	306.20	303.90	317.20	365.09	293.08	168.48	360.00	180.00	303.84	224.64	400.68	472.18	168.48	377.16
	6	339.00	360.00	303.90	344.60	371.52	288.80	198.12	360.00	180.00	303.84	224.64	394.47	404.86	168.48	382.80
	7	360.00	360.00	342.60	341.90	370.35	291.53	224.64	360.00	180.00	308.07	224.64	390.15	410.83	157.95	346.53
	8	382.50	360.00	303.90	303.90	325.36	247.68	168.48	360.00	180.00	303.84	224.64	331.31	431.64	151.70	329.46
	9	457.30	360.00	268.60	303.90	325.36	248.39	168.48	341.16	180.00	303.84	224.64	392.78	445.11	168.48	278.98
	10	443.20	332.00	260.20	303.90	294.48	266.77	168.48	360.00	180.00	303.84	224.64	394.25	422.45	207.68	317.05
	11	479.80	303.90	253.10	303.90	319.72	280.67	168.48	360.00	180.00	303.84	224.64	396.90	389.17	236.16	247.68
	12	451.60	303.90	303.90	303.90	325.36	254.50	168.48	360.00	180.00	303.70	224.64	401.13	388.44	236.16	270.24
	13	417.80	292.60	247.50	303.90	325.36	256.06	168.48	360.00	180.00	371.69	224.64	410.15	379.08	236.16	352.02
	14	360.00	303.90	303.90	303.90	325.36	247.68	168.48	360.00	180.00	303.84	224.64	419.18	374.34	236.16	329.46
	15	362.80	303.90	247.50	303.90	325.36	247.68	168.48	360.00	180.00	303.84	224.64	374.79	419.89	304.07	303.84
	16	392.70	303.90	255.90	322.60	325.36	247.68	168.48	360.00	180.00	303.84	224.64	402.99	403.50	265.77	337.68
	17	419.20	303.90	258.70	360.00	325.36	247.68	168.48	360.00	180.00	303.84	224.64	393.97	437.79	287.46	329.22
	18	410.70	303.90	236.20	360.00	325.36	220.77	168.48	360.00	180.00	303.84	224.64	397.07	439.20	303.84	332.04
	19	427.60	303.90	236.20	360.00	325.36	206.73	168.48	360.00	180.00	303.84	224.64	397.18	419.63	303.84	281.28
	20	427.60	315.10	236.20	360.00	325.36	191.52	179.01	360.00	180.00	303.84	224.64	398.20	444.75	303.84	236.16
	21	427.60	309.50	270.00	360.00	289.17	191.52	224.64	360.00	174.73	303.84	224.64	401.86	360.63	303.84	176.94
	22	385.30	303.90	303.90	369.80	337.63	217.17	224.64	360.00	123.84	303.84	224.64	359.34	394.02	303.84	267.18
	23	415.00	303.90	303.90	360.00	425.74	247.68	224.64	360.00	158.43	303.84	224.64	426.23	401.13	273.24	303.84
	24	408.70	303.90	303.90	371.20	439.20	247.68	224.64	360.00	180.00	303.84	224.64	448.36	401.13	303.84	298.20
	25	371.50	303.90	303.90	382.50	439.20	247.68	224.64	360.00	180.00	303.84	216.26	412.79	315.97	303.84	303.84
	26	313.70	303.90	303.90	367.20	438.72	247.68	224.64	360.00	180.00	320.22	168.48	303.84	360.24	303.84	303.84
	27	358.90	303.90	303.90	412.10	439.20	247.68	224.64	360.00	180.00	345.00	168.48	309.93	356.46	303.84	303.84
	28	333.50	303.90	303.90	409.30	439.20	247.68	224.64	360.00	180.00	303.84	168.48	309.20	329.22	343.62	303.84
	29	337.70	303.90	303.90	415.00	439.20	247.68	224.64	360.00	180.00	303.84	168.48	303.84	399.72	360.00	258.72
	30	343.30	303.90	303.90	415.00	439.20	247.68	224.64	360.00	180.00	303.84	168.48	392.22	405.36	360.00	236.16
DEC	1	371.50	303.90	303.90	342.40	415.23	247.68	225.00	360.00	180.00	303.84	168.48	391.20	391.26	360.00	258.99
	2	371.50	303.90	303.90	322.20	387.03	247.68	225.00	360.00	180.00	303.85	168.48	382.07	388.44	360.00	301.73
	3	371.50	305.30	303.90	343.30	369.63	252.94	225.00	360.00	157.77	303.84	168.48	372.65	378.57	360.00	303.84
	4	357.40	303.90	303.90	339.10	365.18	247.68	225.00	360.00	123.84	303.84	168.48	325.10	303.84	360.00	303.84
	5	363.10	303.90	303.90	354.60	371.52	247.68	225.00	360.00	123.84	364.02	168.48	323.58	316.53	360.00	303.84
	6	371.50	377.20	303.90	351.80	341.21	247.68	225.00	360.00	123.84	297.02	168.48	377.06	394.08	360.00	303.84
	7	371.50	363.10	303.90	351.80	341.43	247.68	225.00	360.00	143.73	269.76	168.48	445.05	395.94	360.00	303.84
	8	371.50	303.90	303.90	303.90	320.76	283.87	225.00	360.00	180.00	224.64	168.48	444.21	401.58	360.00	303.84
	9	359.80	327.30	247.70	303.90	349.01	283.21	225.00	360.00	180.00	224.64	168.48	426.07	385.62	360.00	303.84
	10	371.50	360.00	265.30	355.30	363.99	252.85	225.00	360.00	180.00	251.99	168.48	373.66	388.44	360.00	303.84
	11	353.20	360.00	303.90	390.10	351.78	247.68	225.00	360.00	176.49	292.32	168.48	328.50	365.88	360.00	303.84
	12	351.80	360.00	303.90	407.90	371.52	247.68	225.00	360.00	129.88	292.32	173.16	284.87	330.63	360.00	303.84
	13	354.60	360.00	293.40	385.30	368.70	247.68	225.00	360.00	180.00	292.32	195.86	325.95	408.49	360.00	303.84
	14	358.90	360.00	284.60	377.80	303.84	247.68	180.00	360.00	157.44	305.49	168.48	389.85	390.30	402.30	303.84
	15	358.90	360.00	12.90	368.40	303.84	247.68	168.00	360.00	180.00	360.00	168.48	391.26	431.25	376.92	303.84
	16	356.00	324.90	38.40	371.20	303.84	261.31	168.00	360.00	180.00	360.00	168.48	397.63	406.77	360.00	303.84
	17	361.70	341.30	247.70	374.50	274.23	247.68	168.00	360.00	180.00	368.37	168.48	396.73	400.68	360.00	303.84
	18	371.50	360.00	247.70	371.20	303.84	247.68	168.00	360.00	236.16	303.84	168.48	344.11	356.97	360.00	303.84
	19	357.90	360.00	247.70	367.00	274.96	253.32	168.00	360.00	196.38	303.84	221.64	264.36	335.68	360.00	305.01
	20	315.10	360.00	247.70	297.60	329.22	247.68	168.00	315.44	180.00	388.72	224.64	337.29	398.31	360.00	345.90
	21	351.80	360.00	219.60	269.20	303.84	247.68	168.00	303.84	180.00	398.31	224.64	388.38	398.31	360.00	360.00
	22	303.90	355.70	215.00	303.90	303.84	247.68	168.00	303.84	180.00	372.93	224.64	395.04	369.99	360.00	360.00
	23	303.90	360.00	268.80	303.90	307.37	247.68	168.00	303.84	180.00	363.34	224.64	390.30	320.31	360.00	360.00
	24	303.90	360.00	303.90	303.90	324.99	247.68	168.00	303.84	180.00	344.00	224.64	342.02	325.44	360.00	360.00
	25	303.90	360.00	303.90	303.90	317.38	247.68	168.00	303.84	180.00	303.84	224.64	319.35	303.84	360.00	360.00
	26	303.90	360.00	303.90	303.90	303.84	247.68	168.00	303.84	180.40	333.17	224.64	343.15	329.28	376.92	360.00
	27	303.90	323.30	303.90	303.90	297.78	247.68	168.00	303.84	180.00	303.84	224.64	339.54	308.52	345.90	360.00
	28	303.90	224.60	303.90	303.90	211.96	247.68	174.00	303.84	180.00	303.84	169.07	378.40	303.84	371.28	303.84
	29	239.00	224.60	303.90	303.90	265.64	247.68	168.00	299.16	180.00	303.84	168.48	354.97	303.14	385.38	126.30
	30	217.90	224.60	303.90	303.90	299.85	247.68	188.00	247.68	180.00	303.84	168.48	364.02	305.25	360.00	273.42
	31	303.90	224.60	303.90	303.90	235.23	247.68	203.00	247.68	180.00	303.84	168.48	346.03	303.84	374.10	303.84

APPENDIX B
SANTA MONICA BAY FISH TRAWL DATA

Appendix B-1. Scattergood Generating Station 1986 and 1988 NPDES fish trawl data.

Species	1986 Win	1986 Sum	1988 Win	1988 Sum	Total
Engraulis mordax	3	3442	89		3534
Seriphus politus	633	8	869	172	1682
Genyonemus lineatus	355	3	1021	14	1393
Citharichthys stigmaeus	60	150	274	410	894
Pleuronichthys ritteri	55	80	145	118	398
Paralichthys californicus	51	43	82	30	206
Pleuronichthys verticalis	20	71	51	63	205
Xystreurys liolepis	7	41	17	49	114
Synodus lucioceps	2	9	12	59	82
Sardinops sagax		60			60
Platyrhinoidis triseriata	12		40	7	59
Paralabrax nebulifer	18	8	3	1	30
Hippoglossina stomata		9		18	27
Scorpaena guttata		10	1	13	24
Chromis punctipinnis		22			22
Heterostichus rostratus	1	17			18
Hypsurus caryi	2	13		1	16
Ophidion scrippsi	14				14
Menticirrhus undulatus	5		8		13
Phanerodon furcatus		2	1	10	13
Paralabrax clathratus				12	12
Syngnathus leptorhynchus	9			1	10
Hyperprosopon argenteum	6		3		9
Hypsopsetta guttulata	2		3	4	9
Umbrina roncador	8		1		9
Pleuronichthys coenosus	2		1	4	7
Rhinobatus productus	2		5		7
Squalus acanthias	7				7
Heterodontus francisci		1	5		6
Porichthys myriaster			2	3	5
Mustelus henlei	1		3		4
Sebastes serranoides			3		3
Symphurus atricauda		1		2	3
Amphisticus argenteus			2		2
Atractoscion nobilis				1	1
Cymatogaster aggregata				1	1
Damalichthys vacca		1			1
Halichoeres semicinctus		1			1
Myliobatis californica		1			1
Pleuronectes vetulus		1			1
Porichthys notatus	1				1
Sebastes mystinus			1		1
Squatina californica			1		1
Survey totals	1276	3994	2643	993	8906
Total Species	24	23	26	22	43

Appendix B-1. (continued)

Biomass (kg) of select species caught in trawl

	1986		1988		
Species	Win	Sum	Win	Sum	Total
Paralichthys californicus	25.487	15.848	59.027	21.433	121.794
Genyonemus lineatus	19.372	0.284	19.278	0.653	39.587
Seriphus politus	11.652	0.085	19.224	7.784	38.744
Paralabrax nebulifer	3.572	1.049	0.907	0.141	5.669
Engraulis mordax	0.057	1.786	0.390		2.233
Chromis punctipinnis		1.928			1.928
Hyperprosopon argenteum	0.539		0.286		0.824
Umbrina roncador	0.595		0.059		0.654
Atractoscion nobilis				0.454	0.454
Phanerodon furcatus		0.057	0.113	0.172	0.342
Sardinops sagax		0.085			0.085
Paralabrax clathratus				0.041	0.041
Survey totals	61.274	21.121	99.284	30.677	212.355

Appendix B-2. Hyperion Treatment Plant 1990 to 1995 trawl data.

Species	Date: 20 Jun 1990	29 Aug 1990	5 Dec 1990	23 Jan 1991	28 Mar 1991	28 May 1991	10 Jul 1991	28 Aug 1991	23 Oct 1991	1992	1993	1994	1995	Total
Seriphus politus	54	0	51	50	51	50	50	43	90	238	755	734	860	3026
Genyonomus lineatus	2	0	2	8	50	14	0	0	0	37	216	226	289	844
Paralichthys californicus	0	2	0	0	12	0	2	1	0	2	6	2	2	32

Appendix B-3. Estimated fish population estimates, based on trawl data and net efficiencies.

Stock = 100 X CPUE/Area Swept X 1/Catch Efficiency

Seriphus politus	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	26.38	2827462.599	74588463	621321900	248379583	149176927
Sum 1986	0.33	2827462.599	933063	7772412	3107099	1866125
Win 1988	36.21	2827462.599	102382421	852845565	340933461	204764841
Sum 1988	7.17	2827462.599	20272907	168873314	67508780	40545814
Average	17.5225	2827462.599	49544213	412703298	164982231	99088427

Engraulis mordax	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0.13	2827462.599	367570	3061859	1224009	735140
Sum 1986	143.42	2827462.599	405514686	3377937334	1350363904	811029372
Win 1988	3.71	2827462.599	10489886	87380752	34931321	20979772
Sum 1988	0	2827462.599	0	0	0	0
Average	36.815	2827462.599	104093036	867094986	346629808	208186071

Sardinops sagax	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0	2827462.599	0	0	0	0
Sum 1986	2.5	2827462.599	7068656	58881909	23538626	14137313
Win 1988	0	2827462.599	0	0	0	0
Sum 1988	0	2827462.599	0	0	0	0
Average	0.625	2827462.599	1767164	14720477	5884657	3534328

Genyonemus lineatus	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	14.79	2827462.599	41818172	348345371	139254512	83636344
Sum 1986	0.13	2827462.599	367570	3061859	1224009	735140
Win 1988	42.54	2827462.599	120280259	1001934557	400533262	240560518
Sum 1988	0.58	2827462.599	1639928	13660603	5460961	3279857
Average	14.51	2827462.599	41026482	341750598	136618186	82052965

Umbrina roncador	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0.33	2827462.599	933063	7772412	3107099	1866125
Sum 1986	0	2827462.599	0	0	0	0
Win 1988	0.04	2827462.599	113099	942111	376618	226197
Sum 1988	0	2827462.599	0	0	0	0
Average	0.0925	2827462.599	261540	2178631	870929	523081

Hyperprosopon argenteum	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0.25	2827462.599	706866	5888191	2353863	1413731
Sum 1986	0	2827462.599	0	0	0	0
Win 1988	0.13	2827462.599	367570	3061859	1224009	735140
Sum 1988	0	2827462.599	0	0	0	0
Average	0.095	2827462.599	268609	2237513	894468	537218

Appendix B-3. (continued)

Paralabrax nebulifer	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0.75	2827462.599	2120597	17664573	7061588	4241194
Sum 1986	0.33	2827462.599	933063	7772412	3107099	1866125
Win 1988	0.13	2827462.599	367570	3061859	1224009	735140
Sum 1988	0.04	2827462.599	113099	942111	376618	226197
Average	0.3125	2827462.599	883582	7360239	2942328	1767164

Chromis punctipinnis	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0	2827462.599	0	0	0	0
Sum 1986	0.92	2827462.599	2601266	21668542	8662214	5202531
Win 1988	0	2827462.599	0	0	0	0
Sum 1988	0	2827462.599	0	0	0	0
Average	0.23	2827462.599	650316	5417136	2165554	1300633

Paralichthys californicus	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	2.13	2827462.599	6022495	50167386	20054909	12044991
Sum 1986	1.79	2827462.599	5061158	42159447	16853656	10122316
Win 1988	3.42	2827462.599	9669922	80550451	32200841	19339844
Sum 1988	1.25	2827462.599	3534328	29440954	11769313	7068656
Average	2.1475	2827462.599	6071976	50579560	20219680	12143952

Paralabrax clathratus	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0	2827462.599	0	0	0	0
Sum 1986	0	2827462.599	0	0	0	0
Win 1988	0	2827462.599	0	0	0	0
Sum 1988	0.5	2827462.599	1413731	11776382	4707725	2827463
Average	0.125	2827462.599	353433	2944095	1176931	706866

Atractoscion nobilis	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
Win 1986	0	2827462.599	0	0	0	0
Sum 1986	0	2827462.599	0	0	0	0
Win 1988	0	2827462.599	0	0	0	0
Sum 1988	0.04	2827462.599	113099	942111	376618	226197
Average	0.01	2827462.599	28275	235528	94155	56549

Hyperion Trawls

Paralichthys californicus	CPUE	Source Ratio	Estimated Population	12% Efficiency	30% Efficiency	50% Efficiency
1990	3.5	1502186.235	5257652	43796240	17507981	10515304
1991	3.6875	1502186.235	5539312	46142467	18445908	11078623
1992	1.066	1502186.235	1601331	13339083	5332431	3202661
1994	1	1502186.235	1502186	12513211	5002280	3004372
1995	2.625	1502186.235	3943239	32847180	13130985	7886478
Average	2.313375	1502186.235	3475120	28947750	11572150	6950240

APPENDIX C
CALIFORNIA DEPARTMENT OF FISH AND GAME (CDFG) FISH CATCH BLOCK DATA FOR SANTA MONICA BAY

Appendix C. California Department of Fish and Game (CDFG) fish catch block data for Santa Monica Bay.

Species	Year	Block Number 678	679	701	702	Total
Seriphus politus	1980		0	0		0
	1981		0	0		0
	1982		16	200		216
	1983		0	0		0
	1984		0	0		0
	1985		0	0		0
	1986		0	0		0
	1987		0	0		0
	1988		0	0		0
	1989		0	0		0
	1990		0	0		0
	1991		0	0		0
	1992		0	0		0
	1993		0	0		0
	1994		0	0		0
	Mean		1.1	13.3		14.4
Genyonemus lineatus	1980	0	646	2040	0	2686
	1981	0	600	228	0	828
	1982	0	46	358	14	418
	1983	0	0	154	35	189
	1984	0	0	134	0	134
	1985	0	1	148	0	149
	1986	0	5	776	0	781
	1987	0	0	276	0	276
	1988	0	0	457	0	457
	1989	0	0	307	39	346
	1990	0	0	360	0	360
	1991	0	0	0	0	0
	1992	0	0	250	0	250
	1993	0	97	275	156	528
	1994	0	88	173	133	394
	Mean	0.0	98.9	395.7	25.1	519.7
Scomber japonicus	1980	0	35590	16301	20379	72270
	1981	0	32753	10028	21053	63834
	1982	15	16655	8688	15260	40618
	1983	0	1063	8310	7580	16953
	1984	20	1363	9411	4405	15199
	1985	0	6403	22185	5934	34522
	1986	0	1990	18427	3229	23646
	1987	0	5813	19983	3102	28898
	1988	0	1895	17506	1901	21302
	1989	0	180	8261	3948	12389
	1990	0	1583	26754	6865	35202
	1991	0	1577	15845	5514	22936
	1992	0	1547	20176	4577	26300
	1993	0	1333	35897	8671	45901
	1994	0	1355	10122	4121	15598
	Mean	2.3	7406.7	16526.3	7769.3	31704.5

Appendix C. (continued)

Species	Year	Block Number 678	679	701	702	Total
Paralabrax nebulifer	1980	0	13220	5717	2140	21077
	1981	0	13348	5508	1921	20777
	1982	115	13133	8532	4685	26465
	1983	59	780	4004	403	5246
	1984	0	1826	9069	1701	12596
	1985	0	11373	22807	12980	47160
	1986	0	8223	24118	10969	43310
	1987	0	10440	28085	12844	51369
	1988	0	2396	24795	4139	31330
	1989	0	1098	30957	13755	45810
	1990	0	2927	26298	11073	40298
	1991	5	1742	28446	16033	46226
	1992	0	3569	33923	9473	46965
	1993	0	1589	24122	9800	35511
	1994	0	2862	16644	10910	30416
	Mean	11.9	5901.7	19535.0	8188.4	33637.1
Paralabrax clathratus	1980	72	1864	980	106	3022
	1981	0	3669	3828	851	8348
	1982	25	4242	3384	2367	10018
	1983	22	963	2772	283	4040
	1984	0	1102	1900	610	3612
	1985	0	5846	7377	1734	14957
	1986	0	4682	11215	4045	19942
	1987	0	1094	11260	3117	15471
	1988	0	429	10492	1575	12496
	1989	0	593	14360	3877	18830
	1990	0	2382	12494	2979	17855
	1991	0	520	7318	1252	9090
	1992	0	1405	12290	2582	16277
	1993	0	184	6035	995	7214
	1994	0	388	3971	1154	5513
	Mean	7.9	1957.5	7311.7	1835.1	11112.3
Paralichthys californicus	1980	0	810	192	37	1039
	1981	0	1522	502	45	2069
	1982	0	1315	933	159	2407
	1983	0	17	111	7	135
	1984	0	115	157	37	309
	1985	0	411	658	463	1532
	1986	0	342	747	198	1287
	1987	0	264	638	369	1271
	1988	0	760	1781	529	3070
	1989	0	214	1527	645	2386
	1990	0	341	801	289	1431
	1991	0	196	565	214	975
	1992	0	40	156	76	272
	1993	0	126	600	261	987
	1994	0	175	344	228	747
	Mean	0.0	443.2	647.5	237.1	1327.8

APPENDIX D
LOS ANGELES TIMES SANTA MONICA BAY FISH LANDINGS DATA

Appendix D. Los Angeles Times Santa Monica Bay fish landings data.

Species	Year	Santa Monica Bay Landings	Long Beach and Seal Beach Landings	Total
Trachurus symmetricus	1959	20	0	20
	1993	3787	48	3835
	1994	3835	45	3880
	Mean	2547.3	31.0	2578.3
Seriphus politus	1975	0	210	210
	1983	0	4960	4960
	1991	0	125	125
	1993	0	10	10
	1994	0	34	34
	Mean	0.0	1067.8	1067.8
Genyonemus lineatus	1959	178	0	178
	1967	55	0	55
	1983	0	2230	2230
	1991	280	8238	8518
	1992	275	10056	10331
	1993	220	3015	3235
	1994	25	24662	24687
	Mean	147.6	6885.9	7033.4
Scomber japonicus	1959	3241	0	3241
	1967	41578	2623	44201
	1975	66426	14917	81343
	1983	177222	92267	269489
	1991	126616	89484	216100
	1992	187700	72128	259828
	1993	214967	49996	264963
	1994	235218	80864	316082
	Mean	131621.0	50284.9	181905.9
Paralabrax nebulifer	1959	42089	6341	48430
	1967	89059	61860	150919
	1975	7099	34984	42083
	1983	48348	26338	74686
	1991	102894	84616	187510
	1992	91936	84841	176777
	1993	80871	52792	133663
	1994	60367	50469	110836
	Mean	65332.9	50280.1	115613.0
Paralabrax clathratus	1959	58042	1038	59080
	1967	138245	3371	141616
	1975	64064	35134	99198
	1983	18393	6340	24733
	1991	37881	4435	42316
	1992	56369	16811	73180
	1993	35240	11371	46611
	1994	31126	9223	40349
	Mean	54920.0	10965.4	65885.4

Appendix D. (continued)

Species	Year	Santa Monica Bay Landings	Long Beach and Seal Beach Landings	Total
Sebastes sp.	1959	146845	7379	154224
	1967	648603	65759	714362
	1975	1268307	458540	1726847
	1983	221583	122756	344339
	1991	282755	193565	476320
	1992	257256	191483	448739
	1993	199535	123581	323116
	1994	207534	146004	353538
	Mean	404052.3	163633.4	567685.6
Paralichthys californicus	1959	11264	1322	12586
	1967	17837	12085	29922
	1975	4268	1857	6125
	1983	1055	263	1318
	1991	3138	253	3391
	1992	1159	101	1260
	1993	2331	152	2483
	1994	2000	232	2232
	Mean	5381.5	2033.1	7414.6

Appendix D. (continued)

Species	Year	Paradise Cove	Paradise Cove - Barge	Malibu	Malibu - Barge	Santa Monica	Santa Monica - Barge	Marina del Rey	Hermosa Beach	Hermosa Pier	Redondo	Redondo - Barge	Long Beach - Barge	Long Beach - Belmont	Long Beach - Alamitos Bay	Seal Beach	Seal Beach - Barge
Trachurus symmetricus	1959	20									0	0	0	0		0	
	1993	0									1	3786	0	48		0	
	1994	0									30	3805	20	0		25	
	Mean	6.7									10.3	2530.3	6.7	16.0		8.3	
Seriphus politus	1975												0	0			210
	1983												4960	0			0
	1991												0	125			0
	1993												0	10			0
	1994												0	34			0
	Mean												992.0	33.8			42.0
Genyonemus lineatus	1959				178							0	0	0			
	1967				55							0	0	0			
	1983				0							0	2230	0			
	1991				0							280	6766	1472			
	1992				0							275	10019	37			
	1993				0							220	3000	15			
	1994				0							25	23970	692			
	Mean				33.3							114.3	6569.3	316.6			
Scomber japonicus	1959	611	0	50	2480	0	0	0	0	0	0	100	0	0		0	0
	1967	33	444	55	728	0	0	44	15	75	38	40146	1808	173		256	386
	1975	0	0	8	0	667	34226	33	0	0	2703	28789	0	5556		4749	4612
	1983	0	0	624	0	1194	0	33848	0	0	30257	111299	39081	52446		420	320
	1991	0	0	0	0	0	0	14505	0	0	13753	98358	26791	27294		35399	0
	1992	0	0	320	0	0	0	15655	0	0	56868	114857	35188	14947		21993	0
	1993	0	0	3559	0	0	0	19496	0	0	48110	143802	9143	28045		12808	0
	1994	0	0	1372	0	0	0	9095	0	0	25143	199608	44880	21028		14956	0
	Mean	80.5	55.5	748.5	401.0	232.6	4278.3	11584.5	1.9	9.4	22109.0	92119.9	19611.4	18686.1		11322.6	664.8
Paralabrax nebulifer	1959	28361	1920	770	24	9546	0	0	0	0	1468	0	0	486	0	5755	100
	1967	13033	3944	8477	1287	23171	0	2943	392	5834	25304	4674	1776	20557	0	37584	1943
	1975	1812	0	1863	0	2789	76	0	0	0	550	9	2	3545	0	30848	589
	1983	34	0	441	0	168	0	13691	0	0	31487	2527	909	25374	0	49	6
	1991	0	0	8845	0	0	0	52333	0	0	41153	563	582	33148	0	50886	0
	1992	0	0	10399	0	0	0	47589	0	0	33606	342	146	32635	0	52060	0
	1993	0	0	7844	0	0	0	42619	0	0	30011	397	42	19637	0	33113	0
	1994	0	0	5208	0	0	0	33563	0	0	21067	529	72	27936	75	22386	0
	Mean	5405.0	733.0	5480.9	163.9	4459.3	9.5	24092.3	49.0	729.3	23080.8	1130.1	441.1	20414.8	9.4	29085.1	329.8
Paralabrax clathratus	1959	20529	862	17724	8	713	0	0			18206	0	0	203	0	835	0
	1967	31911	5746	30001	3006	11	0	0			66082	1488	183	339	0	2830	19
	1975	8773	0	9082	0	3278	927	0			42004	0	0	34065	0	1067	2
	1983	27	0	209	0	2	0	15576			2544	35	1	6334	0	5	0
	1991	0	0	4648	0	0	0	8278			24829	126	0	1990	0	2445	0
	1992	0	0	9336	0	0	0	18130			28689	214	0	7716	0	9095	0
	1993	0	0	7663	0	0	0	9412			18031	134	6	3987	0	7378	0
	1994	0	0	4985	0	0	0	5238			20830	73	4	3147	704	5368	0
	Mean	7655.0	826.0	10456.0	376.8	500.5	115.9	7079.3			27651.9	258.8	24.3	7222.6	88.0	3627.9	2.6

Appendix D. (continued)

Species	Year	Paradise Cove	Paradise Cove - Barge	Malibu	Malibu - Barge	Santa Monica	Santa Monica - Barge	Marina del Rey	Hermosa Beach	Hermosa Pier	Redondo	Redondo - Barge	Long Beach - Barge	Long Beach - Belmont	Long Beach - Alamitos Bay	Seal Beach	Seal Beach - Barge
Sebastes sp.	1959	61521	2782	26371	210	14345	0	0	0	0	41616	0	0	689	0	6590	100
	1967	154383	11818	95927	9593	48080	0	36383	392	5834	240305	45888	2180	21037	0	40580	1962
	1975	277536	0	147180	0	44724	13816	100390	0	0	447579	237082	2	159431	0	297151	1956
	1983	6977	0	9233	0	217	0	86419	0	0	112076	6661	10454	106315	0	5981	6
	1991	0	0	30583	0	0	0	106634	0	0	139712	5826	7348	61874	0	124343	0
	1992	0	0	33647	0	0	0	107423	0	0	112498	3688	10165	59260	0	122058	0
	1993	0	0	25226	0	0	0	87635	0	0	82475	4199	3048	41048	0	79485	0
	1994	0	0	22492	0	0	0	85165	0	0	97125	2732	24058	40153	2060	79733	0
	Mean	62552.1	1825.0	48832.4	1225.4	13420.8	1727.0	76258.6	49.0	729.3	159173.3	38259.5	7156.9	61225.9	257.5	94490.1	503.0
Paralichthys californicus	1959	1594	66	3038	1111	3161	0	0	0	0	2294	0	0	237	0	1055	30
	1967	4232	209	3741	422	1982	0	233	63	466	2869	3620	371	4011	0	5785	1918
	1975	377	0	1670	0	1477	418	3	0	0	321	2	36	92	0	413	1316
	1983	1	0	47	0	19	0	600	0	0	370	18	180	78	0	0	5
	1991	0	0	502	0	0	0	1901	0	0	716	19	11	105	0	137	0
	1992	0	0	186	0	0	0	739	0	0	231	3	7	26	0	68	0
	1993	0	0	139	0	0	0	1822	0	0	363	7	4	55	0	93	0
	1994	0	0	385	0	0	0	1230	0	0	377	8	32	118	1	81	0
	Mean	775.5	34.4	1213.5	191.6	829.9	52.3	816.0	7.9	58.3	942.6	459.6	80.1	590.3	0.1	954.0	408.6

APPENDIX E
SCATTERGOOD GENERATING STATION
HEAT TREATMENT DATA
NOVEMBER 1989 TO NOVEMBER 1995

Appendix E. Scattergood Generating Station heat treatment data, November 1989 to 1995.

	08 nov 89		16 jan 90		17 mar 90		26 apr 90		20 jun 90	
Species	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Trachurus symmetricus	1	0.181							5	1.500
Seriphus politus	184	1.859	171	4.760	1956	96.440	1696	64.400	992	114.800
Atherinops affinis									956	119.500
Atherinopsis californiensis			2	0.450	34	5.170	4	0.600	87	32.400
Engraulis mordax	22	0.091	3	0.140						
Sardinops sagax			1	0.050					2	0.380
Genyonemus lineatus					26	3.310	10	0.300	2	0.880
Xenistius californiensis	99	0.499	89	1.590	88	0.950	1	0.010	20	4.130
Umbrina roncador							31	16.500	4	3.380
Hyperprosopon argenteum	3	0.181	24	1.950	157	11.250	113	5.900	73	18.750
Anisotremus davidsonii	4	0.272			12	2.000	1	1.500	40	60.250
Scomber japonicus									2	1.000
Paralabrax nebulifer					106	36.240	10	3.600	53	60.250
Chromis punctipinnis					34	3.900	8	0.400	14	7.060
Paralabrax clathratus	2	0.091			10	2.220	3	0.700	75	70.310
Leuresthes tenuis									324	17.800
Porichthys notatus							159	27.850	113	20.000
Phanerodon furcatus							21	1.700	48	15.250
Cheilotrema saturnum	10	0.998	4	0.230	1	0.360	1	0.200	9	4.000
Peprilus simillimus					55	2.950			92	11.130
Medialuna californiensis	1	0.272			5	1.130			2	2.250
Embiotoca jacksoni	3	0.363			13	5.400	28	1.100	11	6.250
Rhacochilus toxotes	2	0.680			9	3.810	7	3.300	5	6.130
Scorpaena guttata							1	0.150	10	6.000
Oxyjulis californica										
Damalichthys vacca			3	0.360	17	3.400	2	0.950	12	7.250
Cymatogaster aggregata							1	0.100	10	1.000
Girella nigricans					5	2.770	1	1.200	2	1.750
Myliobatis californica									10	15.000
Atractoscion nobilis			1	0.140	1	0.090	1	0.300	1	0.630
Sebastes paucispinis										
Urolophus halleri							2	1.450	2	2.310
Halichoeres semicinctus					8	1.950	1	0.400	2	2.250
Menticirrhus undulatus					1	0.230			1	0.630
Pleuronichthys ritteri					5	0.590	2	0.250		
Sphyraena argentea									34	18.250
Platyrhinoidis triseriata					10	5.850	2	0.400	1	0.690
Mustelus californicus					1	1.040	2	2.500	12	27.060
Brachyistius frenatus	3	0.136			1	0.050				
Heterostichus rostratus					2	0.180			4	0.380
Hypsoblennius gilberti										
Scorpaenichthys marmoratus									2	0.750
Paralichthys californicus					1	0.090	2	0.200	3	6.250
Rhinobatus productus					1	1.090			1	3.500
Hypsurus caryi	1	0.181							1	0.500
Hermosilla azurea										
Sebastes auriculatus					1	0.360			1	0.250
Sebastes rastrelliger					2	0.590	1	0.400		
Anchoa compressa										
Hypsoblennius, sp.										
Triakis semifaciata									1	7.630
Hypsopsetta guttulata					2	0.410				
Heterodontus francisci										
Sebastes serranoides							1	0.010		
Semicossyphus pulcher										
Ophidion scrippae										
Mustelus henlei										

Appendix E. (continued)

	08 nov 89		16 jan 90		17 mar 90		26 apr 90		20 jun 90	
Species	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Balistes polylepis									1	3.440
Porichthys myriaster	1	0.590								
Pleuronichthys verticalis					2	0.230				
Chilara taylori							2	0.200		
Paralabrax maculatofasciata										
Hypsoblennius jenkinsi										
Torpedo californica										
Squalis acanthias										
Xystreurys liolepis										
Hexagrammos decagrammus										
Syngnathus californiensis										
Cephaloscyllium ventriosum										
Roncador stearnsii										
Hippoglossina stomata										
Pleuronichthys coenosus										
Strongylura exilis										
Syngnathus leptorhynchus										
Gibbonsia metzi										
Micrometrus minimus										
Clinocottus analis										
Citharichthys stigmaeus										
Syngnathus sp.										
Survey totals	336	6.395	298	9.670	2566	194.050	2114	136.570	3040	682.920
Total Species	14		9		30		29		42	

Appendix E. (continued)

	29 aug 90		05 dec 90		23 jan 91		28 mar 91		28 may 91	
Species	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Trachurus symmetricus	1	0.400	7	0.600					1	0.050
Seriphus politus			336	63.300	2048	98.350	5141	226.850	3035	121.400
Atherinops affinis	2	0.250			284	13.100	65	2.500	4627	185.100
Atherinopsis californiensis			4	0.800	18	3.200	118	20.750		
Engraulis mordax									5	0.100
Sardinops sagax	4	0.600	2	0.300	1	0.250				
Genyonemus lineatus			2	0.200	8	0.500	194	32.150	14	0.600
Xenistius californiensis	201	18.900	2309	25.400	35	0.500	109	2.400	56	2.300
Umbrina roncador	24	10.890	17	1.950	22	3.700	26	7.400		
Hyperprosopon argenteum	3	0.400	69	3.800	123	11.600	66	8.700	18	1.950
Anisotremus davidsonii	753	380.000	180	58.000	8	1.050	19	9.600	2	1.000
Scomber japonicus			6	0.800						
Paralabrax nebulifer	144	70.550	61	15.600	22	8.000	56	26.100	192	122.400
Chromis punctipinnis	376	48.240	69	2.000	23	1.800	97	15.700	163	23.600
Paralabrax clathratus	363	195.580	115	17.500	10	2.450	1	1.000	15	11.200
Leuresthes tenuis					12	0.100	277	6.650		
Porichthys notatus					1	0.700			453	58.700
Phanerodon furcatus			13	2.500	32	4.400	23	4.500	48	3.700
Cheilotrema saturnum	11	1.810	73	8.900	9	0.650	6	0.950	4	1.400
Peprilus simillimus					2	0.200	222	11.100		
Medialuna californiensis	25	7.600	10	3.350			2	0.950		
Embiotoca jacksoni	4	1.200	2	0.600			8	2.450	11	3.300
Rhacochilus toxotes	2	1.130	3	1.400	2	1.850	3	1.700		
Scorpaena guttata	13	3.100	7	0.600	3	1.200	5	0.150	7	2.200
Oxyjulis californica									2	0.100
Damalichthys vacca	4	2.100	11	4.200	7	0.450	8	3.700	7	3.500
Cymatogaster aggregata			2	0.010			2	0.100	3	0.150
Girella nigricans	25	15.540	14	6.800			11	8.100	12	8.900
Myliobatis californica	1	4.000			1	3.100	5	6.500	6	22.000
Atractoscion nobilis	2	2.490	4	1.500			8	1.600		
Sebastes paucispinis									42	0.350
Urolophus halleri	1	0.450	1	0.700	2	0.850	8	3.900	6	4.100
Halichoeres semicinctus	1	0.500					3	0.900	14	5.450
Menticirrhus undulatus	5	2.490	2	0.400	1	1.500	6	1.500	1	0.450
Pleuronichthys ritteri					3	0.400	29	3.800	4	0.650
Sphyraena argentea	3	1.200	15	5.700	2	0.300	6	0.400	1	0.150
Platyrhinoidis triseriata					4	1.300	21	11.100	5	3.500
Mustelus californicus	6	11.800					3	3.000	6	8.800
Brachyistius frenatus			1	0.010	7	0.400	4	0.100		
Heterostichus rostratus					3	0.300	3	0.200	3	0.100
Hypsoblennius gilberti			1	0.010			1	0.050		
Scorpaenichthys marmoratus			2	0.950			1	0.650	7	1.300
Paralichthys californicus	2	0.500					14	3.000		
Rhinobatus productus	2	4.700					1	8.000	4	9.700
Hypsurus caryi							2	0.500	11	0.400
Hermosilla azurea	21	10.000	1	0.050						
Sebastes auriculatus					3	0.850	1	0.300	2	0.800
Sebastes rastrelliger									6	1.000
Anchoa compressa					10	0.100	1	0.010		
Hypsoblennius, sp.	19	0.060								
Triakis semifaciata	1	1.500					3	21.800	1	12.700
Hypsopsetta guttulata	2	0.800								
Heterodontus francisci									4	5.900
Sebastes serranoides										
Semicossyphus pulcher										
Ophidion scrippae							5	0.400		
Mustelus henlei			1	0.900						

Appendix E. (continued)

Species	29 aug 90 No.	29 aug 90 Wt.	05 dec 90 No.	05 dec 90 Wt.	23 jan 91 No.	23 jan 91 Wt.	28 mar 91 No.	28 mar 91 Wt.	28 may 91 No.	28 may 91 Wt.
Balistes polylepis	1	1.900								
Porichthys myriaster	1	0.110					1	0.030		
Pleuronichthys verticalis										
Chilara taylori										
Paralabrax maculatofasciata										
Hypsoblennius jenkinsi					1	0.010				
Torpedo californica										
Squalis acanthias							2	2.200		
Xystreurys liolepis										
Hexagrammos decagrammus										
Syngnathus californiensis										
Cephaloscyllium ventriosum							1	2.850		
Roncador stearnsii										
Hippoglossina stomata									1	0.450
Pleuronichthys coenosus										
Strongylura exilis							1	0.250		
Syngnathus leptorhynchus										
Gibbonsia metzi							1	0.050		
Micrometrus minimus										
Clinocottus analis										
Citharichthys stigmaeus										
Syngnathus sp.										
Survey totals	2023	800.790	3340	228.830	2707	163.160	6590	466.590	8799	629.450
Total Species	32		31		31		47		38	

Appendix E. (continued)

Species	10 jul 91		28 aug 91		23 Oct 91		31 jan 92 0900-1300		29 apr 92 0815-1230	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Trachurus symmetricus			1	0.200						
Seriphus politus	1358	81.500	43	3.000	90	1.100	910	41.310	2	0.004
Atherinops affinis	1606	51.400	456	26.500	31	1.300			2654	97.940
Atherinopsis californiensis							66	10.820	4	0.394
Engraulis mordax	5	0.100	1568	18.000	943	7.400	241	1.710	11647	76.290
Sardinops sagax			1	0.150					1	0.032
Genyonemus lineatus							37	3.430		
Xenistius californiensis	40	3.400	88	6.700	7	0.900	4	0.070		
Umbrina roncador			19	10.950			2	0.660		
Hyperprosopon argenteum	20	2.200	34	1.850	19	0.900	1362	26.360		
Anisotremus davidsonii	31	24.100	220	123.900	85	44.500	16	7.990	2	1.110
Scomber japonicus					6	0.900			79	4.650
Paralabrax nebulifer	68	44.800	29	9.800	36	10.700	42	16.560	87	43.120
Chromis punctipinnis	53	8.200	12	1.500	18	0.400	13	0.980	30	2.670
Paralabrax clathratus	23	11.800	79	16.200	44	8.400	14	2.710	8	3.140
Leuresthes tenuis										
Porichthys notatus	70	6.500	1	0.100						
Phanerodon furcatus	68	2.800	28	0.800	123	4.500	27	2.270	4	0.285
Cheilotrema saturnum	8	1.600	8	1.450	9	1.600	13	1.560	1	0.435
Peprilus simillimus							13	0.910		
Medialuna californiensis	5	1.700	10	2.950	10	4.300	4	1.530	1	0.269
Embiotoca jacksoni	1	0.100	9	2.450	14	1.500	5	0.840	1	0.134
Rhacochilus toxotes	37	7.000	8	1.450	5	0.900	87	16.860		
Scorpaena guttata	2	0.500	1	0.350	3	1.900	3	0.575		
Oxyjulis californica	2	0.100	2	0.070			6	0.260	8	0.387
Damalichthys vacca	54	2.000	5	0.800	4	0.400	16	2.722		
Cymatogaster aggregata	12	0.400	3	0.100	4	0.100	7	0.170		
Girella nigricans	6	4.600	7	4.250	1	0.300	2	1.200	6	4.120
Myliobatis californica	4	1.000			1	3.600	1	0.550	6	2.039
Atractoscion nobilis							8	1.300		
Sebastes paucispinis	75	2.800	17	0.800	2	0.100				
Urolophus halleri	4	2.100			1	0.500	1	0.570	8	5.090
Halichoeres semicinctus	1	0.600	1	0.500	4	0.600	1	0.410	2	0.295
Menticirrhus undulatus										
Pleuronichthys ritteri							10	0.498		
Sphyraena argentea			3	0.700			2	0.095		
Platyrhinoidis triseriata	1	0.700					7	4.050	2	0.640
Mustelus californicus	8	10.000	5	11.700						
Brachyistius frenatus							4	0.082		
Heterostichus rostratus							8	0.330	2	0.085
Hypsoblennius gilberti							3	0.019		
Scorpaenichthys marmoratus	3	1.400	1	0.650	1	0.500	2	2.650	1	0.056
Paralichthys californicus	2	2.300	1	1.250			1	0.060		
Rhinobatus productus	5	8.900					1	1.120		
Hypsurus caryi	1	0.100					9	0.240		
Hermosilla azurea										
Sebastes auriculatus							1	0.410		
Sebastes rastrelliger	1	0.300							5	1.690
Anchoa compressa										
Hypsoblennius, sp.										
Triakis semifaciata										
Hypsopsetta guttulata			1	0.450			1	0.350		
Heterodontus francisci										
Sebastes serranoides							4	0.240		
Semicossyphus pulcher										
Ophidion scrippae										
Mustelus henlei			1	2.400			1	1.560		

Appendix E. (continued)

Species	10 jul 91		28 aug 91		23 Oct 91		31 jan 92 0900-1300		29 apr 92 0815-1230	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Balistes polylepis	2	3.800								
Porichthys myriaster										
Pleuronichthys verticalis										
Chilara taylori										
Paralabrax maculatofasciata										
Hypsoblennius jenkinsi									2	0.011
Torpedo californica										
Squalis acanthias										
Xystreurys liolepis							1	0.280		
Hexagrammos decagrammus	2	0.100								
Syngnathus californiensis							1	0.004		
Cephaloscyllium ventriosum										
Roncador stearnsii										
Hippoglossina stomata										
Pleuronichthys coenosus										
Strongylura exilis										
Syngnathus leptorhynchus			1	0.050						
Gibbonsia metzi										
Micrometrus minimus										
Clinocottus analis										
Citharichthys stigmaeus							1	0.006		
Syngnathus sp.										
Survey totals	3578	288.900	2663	252.020	1461	97.300	2958	156.315	14563	244.886
Total Species	33		32		24		43		24	

Appendix E. (continued)

Species	08 jul 92 0930-1400 No.	Wt.	03 sep 92 0900-1400 No.	Wt.	14 oct 92 0900-1200 No.	Wt.	13 jan 93 0900-1500 No.	Wt.	20 apr 93 0930-1400 No.	Wt.
Trachurus symmetricus	1	0.009	23	2.450	1	0.039	28	1.890		
Seriphus politus	14	0.484			22	0.460	691	19.970	611	14.280
Atherinops affinis	2383	109.240	1	0.044			84	3.240	3	0.141
Atherinopsis californiensis			264	54.140			70	10.180	20	3.970
Engraulis mordax					4	0.032				
Sardinops sagax	21	1.306	2	1.590	1	0.014	1713	97.920	1	0.130
Genyonemus lineatus							52	5.360	18	3.490
Xenistius californiensis			60	5.150	10	0.680	104	2.100	3	0.040
Umbrina roncador	6	3.160	106	35.110			27	2.130		
Hyperprosopon argenteum							121	11.060	14	1.670
Anisotremus davidsonii			292	165.760	18	9.350	43	21.922		
Scomber japonicus	21	2.950					70	6.850		
Paralabrax nebulifer	73	22.780	41	14.380	25	6.780	54	14.530		
Chromis punctipinnis	26	3.060	119	6.020	151	1.350	30	3.560	1	0.135
Paralabrax clathratus	30	9.590	61	12.582	29	5.520	25	7.360		
Leuresthes tenuis					4	0.025	2	0.020	3	0.050
Porichthys notatus	26	1.580								
Phanerodon furcatus										
Cheilotrema saturnum			6	0.980	2	0.184	16	2.080	1	0.057
Peprilus simillimus							33	1.580	1	0.078
Medialuna californiensis	10	1.758	26	6.320	20	5.000	8	2.500		
Embiotoca jacksoni	3	0.446	3	0.666			2	0.680		
Rhacochilus toxotes	1	0.048					1	0.430		
Scorpaena guttata	1	0.059	1	0.057	2	0.720	7	0.910	2	0.123
Oxyjulis californica	18	0.936			1	0.025				
Damalichthys vacca							1	0.270		
Cymatogaster aggregata	1	0.012							1	0.043
Girella nigricans	1	0.637	3	2.600	2	1.360	12	8.150		
Myliobatis californica	8	3.960	7	11.400						
Atractoscion nobilis							4	0.620		
Sebastes paucispinis										
Urolophus halleri	11	8.920	1	0.490	1	0.560	7	2.690		
Halichoeres semicinctus	7	1.111	4	0.554	1	0.132	3	1.380		
Menticirrhus undulatus			7	2.650			1	0.900		
Pleuronichthys ritteri							11	0.750	13	1.640
Sphyraena argentea			3	1.980	3	0.054	4	0.190	1	0.101
Platyrhinoidis triseriata	2	2.850			1	0.310	2	1.370		
Mustelus californicus	6	8.200								
Brachyistius frenatus									1	0.057
Heterostichus rostratus			1	0.063					1	0.037
Hypsoblennius gilberti	2	0.004	7	0.011			30	0.044		
Scorpaenichthys marmoratus			1	0.629			2	1.090		
Paralichthys californicus	1	1.560								
Rhinobatus productus	2	6.170	2	3.950						
Hypsurus caryi										
Hermosilla azurea										
Sebastes auriculatus					1	0.012	1	0.170		
Sebastes rastrelliger										
Anchoa compressa	3	0.206					3	0.004		
Hypsoblennius, sp.										
Triakis semifaciata	1	5.000	1	3.050						
Hypsopsetta guttulata										
Heterodontus francisci							1	3.520		
Sebastes serranoides										
Semicossyphus pulcher										
Ophidion scrippae										
Mustelus henlei										

Appendix E. (continued)

Species	08 jul 92 0930-1400 No.	Wt.	03 sep 92 0900-1400 No.	Wt.	14 oct 92 0900-1200 No.	Wt.	13 jan 93 0900-1500 No.	Wt.	20 apr 93 0930-1400 No.	Wt.
Balistes polylepis										
Porichthys myriaster										
Pleuronichthys verticalis										
Chilara taylori										
Paralabrax maculatofasciata			1	0.682						
Hypsoblennius jenkinsi										
Torpedo californica										
Squalis acanthias										
Xystreurys liolepis										
Hexagrammos decagrammus										
Syngnathus californiensis										
Cephaloscyllium ventriosum										
Roncador stearnsii										
Hippoglossina stomata										
Pleuronichthys coenosus										
Strongylura exilis										
Syngnathus leptorhynchus										
Gibbonsia metzi										
Micrometrus minimus										
Clinocottus analis										
Citharichthys stigmaeus										
Syngnathus sp.										
Survey totals	2679	196.036	1043	333.308	299	32.607	3263	237.420	695	26.042
Total Species	27		26		20		35		17	

Appendix E. (continued)

Species	14 may 93 '0930 No.	Wt.	19 aug 93 0900-1500 No.	Wt.	09 nov 93 0900-1500 No.	Wt.	22 dec 93 0850-1400 No.	Wt.	24 feb 94 1030-1530 No.	Wt.
Trachurus symmetricus	1	0.037	2	0.103	2	0.110	1	0.021	12	0.289
Seriphus politus	1	0.069	43	1.920	878	28.410	3086	84.080	3231	78.190
Atherinops affinis	89	3.400	4	0.291	457	13.900	297	8.710	672	58.870
Atherinopsis californiensis			1	0.116	11984	1372.220	339	35.850	19	2.560
Engraulis mordax										
Sardinops sagax					2628	149.930	438	32.120	80	9.200
Genyonemus lineatus					5	0.169	156	9.340	14	1.220
Xenistius californiensis			95	8.290	1285	59.590	363	3.990	63	0.870
Umbrina roncador			5	1.748	15	1.580	161	7.280	7	0.373
Hyperprosopon argenteum	1	0.005			25	1.120	198	14.940	28	1.800
Anisotremus davidsonii			811	391.410	81	51.620	40	20.340	4	0.183
Scomber japonicus	1	0.140			761	52.000	465	13.790	147	12.830
Paralabrax nebulifer	1	0.016	57	42.500	403	136.960	42	8.940	6	1.670
Chromis punctipinnis			9	0.852	273	30.860	24	1.555	2	0.195
Paralabrax clathratus			81	24.850	52	10.993	10	1.324	4	1.040
Leuresthes tenuis	2	0.029					18	0.387		
Porichthys notatus	12	1.890	6	0.667						
Phanerodon furcatus			1	0.133	3	0.093	8	0.279	11	0.411
Cheilotrema saturnum			25	5.000	68	5.850	50	3.020	22	1.050
Peprilus simillimus							16	0.922	4	0.206
Medialuna californiensis			7	1.835	33	10.300	1	0.341		
Embiotoca jacksoni			2	0.619	7	1.560	1	0.258	3	0.460
Rhacochilus toxotes			4	2.176	21	1.820	2	0.258		
Scorpaena guttata			7	1.368	29	4.460	13	1.760		
Oxyjulis californica			107	4.110	7	0.350	8	0.239	3	0.092
Damalichthys vacca			8	3.519						
Cymatogaster aggregata					2	0.030	6	0.069		
Girella nigricans			6	3.223	19	13.260	4	3.300		
Myliobatis californica			3	1.684			1	2.620		
Atractoscion nobilis			1	1.520	28	4.290	60	10.690	4	0.749
Sebastes paucispinis										
Urolophus halleri			3	2.083	2	0.950	10	4.690	1	0.970
Halichoeres semicinctus	1	0.153	17	3.420	12	1.620	3	0.759		
Menticirrhus undulatus			1	0.220	1	0.317	62	3.160	1	0.045
Pleuronichthys ritteri	1	0.053			9	1.110	1	0.103		
Sphyraena argentea							3	0.215	6	0.486
Platyrhinoidis triseriata			1	0.282	3	1.120	1	0.500	1	0.016
Mustelus californicus			1	2.000						
Brachyistius frenatus							1	0.040		
Heterostichus rostratus	1	0.019			1	0.139	10	0.178		
Hypsoblennius gilberti			5	0.011	1	0.002				
Scorpaenichthys marmoratus			2	0.760	2	1.050	1	0.785	1	0.440
Paralichthys californicus	1	0.097	1	1.590	2	0.262	2	0.367		
Rhinobatus productus			2	8.850	1	1.710				
Hypsurus caryi										
Hermosilla azurea			1	0.520						
Sebastes auriculatus							4	1.310		
Sebastes rastrelliger					2	0.523				
Anchoa compressa									1	0.007
Hypsoblennius, sp.										
Triakis semifaciata	1	1.420								
Hypsopsetta guttulata			1	0.260						
Heterodontus francisci										
Sebastes serranoides										
Semicossyphus pulcher					5	1.630	1	0.063		
Ophidion scrippae							2	0.016		
Mustelus henlei										

Appendix E. (continued)

Species	14 may 93 '0930 No.	Wt.	19 aug 93 0900-1500 No.	Wt.	09 nov 93 0900-1500 No.	Wt.	22 dec 93 0850-1400 No.	Wt.	24 feb 94 1030-1530 No.	Wt.
Balistes polylepis										
Porichthys myriaster				0.459						
Pleuronichthys verticalis										
Chilara taylori							1	0.040		
Paralabrax maculatofasciata			1	0.918						
Hypsoblennius jenkinsi										
Torpedo californica			1	4.720						
Squalis acanthias										
Xystreurys liolepis										
Hexagrammos decagrammus										
Syngnathus californiensis									1	0.004
Cephaloscyllium ventriosum										
Roncador stearnsii			1	1.400						
Hippoglossina stomata										
Pleuronichthys coenosus										
Strongylura exilis										
Syngnathus leptorhynchus										
Gibbonsia metzi										
Micrometrus minimus							1	0.040		
Clinocottus analis										
Citharichthys stigmaeus										
Syngnathus sp.							1	0.005		
Survey totals	113	7.328	1323	525.427	19107	1961.908	5912	278.694	4348	174.226
Total Species	13		36		36		43		27	

Appendix E. (continued)

Species	27 apr 94 0845-1515 No.	Wt.	07 jul 94 1000-1730 No.	Wt.	15 sep 94 0900-1430 No.	Wt.	27 oct 94 0800-1200 No.	Wt.	02 mar 95 0900-1600 No.	Wt.
Trachurus symmetricus	62422	1794.620	6632	450.880	20	2.092			13	0.873
Seriphus politus	1829	58.530	236	6.480	71	1.950	63	0.440	3606	96.740
Atherinops affinis	3108	107.220			1183	51.020	7	0.371	100	5.080
Atherinopsis californiensis	21	2.601	303	10.650	2	0.428	3	0.394	488	39.690
Engraulis mordax	1	0.015					118	0.680		
Sardinops sagax	3572	133.070	1800	90.400	56	15.350	18	0.830	137	8.810
Genyonemus lineatus	12	0.576	5904	53.760					2520	116.070
Xenistius californiensis	13	0.621	46	3.400	290	21.710	279	1.760	1054	9.580
Umbrina roncador	5	0.589	2	0.820	133	29.160			278	18.770
Hyperprosopon argenteum	22	1.560			1	0.036			447	36.450
Anisotremus davidsonii	4	2.730	26	18.990	436	150.100	3	0.024	23	7.920
Scomber japonicus	440	26.860	800	78.600	7	1.043	1	0.156	240	36.120
Paralabrax nebulifer	46	23.630	147	77.430	76	21.430	9	2.310	129	48.840
Chromis punctipinnis	33	3.175	61	7.100	8	0.448			56	7.020
Paralabrax clathratus	1	0.192	28	9.750	73	14.030	10	2.850	22	3.940
Leuresthes tenuis									80	1.360
Porichthys notatus			29	4.270						
Phanerodon furcatus	7	0.421	14	0.650			1	0.035	11	0.552
Cheilotrema saturnum	3	0.191	1	0.120	45	5.100	11	1.220	13	1.010
Peprilus simillimus	1	0.060							5	0.210
Medialuna californiensis					16	4.860	1	0.810	3	1.840
Embiotoca jacksoni	2	0.153	4	0.590	4	0.298	1	0.057	4	1.306
Rhacochilus toxotes	2	0.486	2	1.650	1	0.339			3	1.320
Scorpaena guttata	2	0.464	23	3.880	12	2.460			7	1.440
Oxyjulis californica	11	0.478	11	0.730	2	0.152			2	0.275
Damalichthys vacca					1	0.684	4	0.465	1	0.096
Cymatogaster aggregata	6	0.281	15	0.290					23	0.686
Girella nigricans	4	3.000	3	3.160	5	3.060			4	3.400
Myliobatis californica			10	47.070	9	31.330			13	5.030
Atractoscion nobilis	4	0.897	2	2.220					16	4.520
Sebastes paucispinis										
Urolophus halleri	3	1.544	17	10.170	4	2.700			6	3.250
Halichoeres semicinctus			2	0.420	17	2.680			4	1.400
Menticirrhus undulatus					3	1.540			20	3.650
Pleuronichthys ritteri			3	0.141					13	1.350
Sphyraena argentea							3	0.055	2	0.101
Platyrhinoidis triseriata	2	0.623	1	0.460			3	0.952	1	0.670
Mustelus californicus			13	9.600						
Brachyistius frenatus			27	0.800					9	0.332
Heterostichus rostratus	1	0.024							8	0.457
Hypsoblennius gilberti									1	0.007
Scorpaenichthys marmoratus			3	0.110	1	0.044			2	0.404
Paralichthys californicus					2	1.380			1	2.750
Rhinobatus productus			1	0.780	3	5.750				
Hypsurus caryi			1	0.340						
Hermosilla azurea					2	1.476				
Sebastes auriculatus	1	0.276	1	0.680	1	0.240			4	1.860
Sebastes rastrelliger									3	1.150
Anchoa compressa									2	0.036
Hypsoblennius, sp.										
Triakis semifaciata	3	18.000	1	6.820						
Hypsopsetta guttulata									1	0.228
Heterodontus francisci	1	2.500							1	1.840
Sebastes serranoides	3	1.061								
Semicossyphus pulcher					1	0.870				
Ophidion scrippae										
Mustelus henlei					2	5.360				

Appendix E. (continued)

Species	27 apr 94 0845-1515 No.	Wt.	07 jul 94 1000-1730 No.	Wt.	15 sep 94 0900-1430 No.	Wt.	27 oct 94 0800-1200 No.	Wt.	02 mar 95 0900-1600 No.	Wt.
Balistes polylepis										
Porichthys myriaster										
Pleuronichthys verticalis									2	0.213
Chilara taylori	1	0.031								
Paralabrax maculatofasciata									1	0.013
Hypsoblennius jenkinsi										
Torpedo californica	1	13.000								
Squalis acanthias										
Xystreurys liolepis					1	0.421				
Hexagrammos decagrammus										
Syngnathus californiensis										
Cephaloscyllium ventriosum										
Roncador stearnsii										
Hippoglossina stomata										
Pleuronichthys coenosus									1	0.373
Strongylura exilis										
Syngnathus leptorhynchus										
Gibbonsia metzi										
Micrometrus minimus										
Clinocottus analis									1	0.013
Citharichthys stigmaeus										
Syngnathus sp.										
Survey totals	71587	2199.479	16169	903.211	2488	379.541	535	13.409	9381	479.045
Total Species	34		34		33		17		48	

Appendix E. (continued)

Species	09 jun 95 0830-1230 No.	Wt.	27 jun 95 0800-1331 No.	Wt.	10 oct 95 0700-1530 No.	Wt.	25 oct 95 0900-1600 No.	Wt.	16 nov 95 0800-1300 No.	Wt.
Trachurus symmetricus	21	2.500								
Seriphus politus	5550	88.800	197	5.200			127	3.510	261	8.150
Atherinops affinis	1248	59.780	1961	59.800	655	21.290	963	31.680	133	4.960
Atherinopsis californiensis	620	85.170			1	0.073	2294	121.030	54	4.286
Engraulis mordax			3	0.027			1	0.007		
Sardinops sagax			4	0.145			16	0.658	1	0.053
Genyonemus lineatus	89	10.100								
Xenistius californiensis	215	3.350	39	1.200	395	21.540	287	9.850	23	0.795
Umbrina roncador	8	0.939			4405	553.900	163	36.630	5	0.972
Hyperprosopon argenteum	318	24.750	4	0.282			31	0.950	26	1.050
Anisotremus davidsonii	4	0.073			16	9.280	3	0.234	2	0.170
Scomber japonicus	98	35.150	7	0.476	7	0.896			10	1.700
Paralabrax nebulifer	36	10.450			180	50.930	48	15.710	17	5.290
Chromis punctipinnis	4	0.335			4	0.673	1	0.248	2	0.085
Paralabrax clathratus	26	4.720	11	2.000	79	13.930	16	2.020	2	0.260
Leuresthes tenuis	471	7.470								
Porichthys notatus	6	0.305	4	0.239						
Phanerodon furcatus	13	0.715	12	0.322	1	0.152	5	0.149	4	0.145
Cheilotrema saturnum	5	0.695	2	0.260	12	1.171	8	0.698	11	0.995
Peprilus simillimus	5	0.302								
Medialuna californiensis	5	1.012			26	5.980	4	0.728	1	0.181
Embiotoca jacksoni	43	0.704	21	0.601			3	0.211	6	0.454
Rhacochilus toxotes	4	0.048	1	0.686	1	1.000	1	0.043		
Scorpaena guttata	7	2.100	10	1.530	20	4.330			3	1.394
Oxyjulis californica	1	0.050								
Damalichthys vacca	11	0.154	2	0.281					1	0.086
Cymatogaster aggregata	67	2.650					7	0.114	1	0.016
Girella nigricans					1	0.752				
Myliobatis californica	35	159.900	12	3.920	11	55.240	5	3.690	1	2.850
Atractoscion nobilis	4	0.801								
Sebastes paucispinis										
Urolophus halleri	8	5.200	4	2.600	7	4.370	2	1.155	4	2.950
Halichoeres semicinctus	1	0.326			11	2.720				
Menticirrhus undulatus	3	0.290			4	1.337				
Pleuronichthys ritteri	5	0.507								
Sphyraena argentea	1	0.057					1	0.208		
Platyrhinoidis triseriata	3	3.090								
Mustelus californicus					4	5.960				
Brachyistius frenatus			5	0.074						
Heterostichus rostratus	7	0.419							1	0.023
Hypsoblennius gilberti			2	0.025	2	0.001				
Scorpaenichthys marmoratus	1	0.306			7	1.790				
Paralichthys californicus					1	1.680				
Rhinobatus productus					5	13.610				
Hypsurus caryi	1	0.152								
Hermosilla azurea										
Sebastes auriculatus			1	0.586	1	0.500				
Sebastes rastrelliger	1	0.421								
Anchoa compressa										
Hypsoblennius, sp.										
Triakis semifaciata										
Hypsopsetta guttulata	2	0.349								
Heterodontus francisci	2	5.020								
Sebastes serranoides										
Semicossyphus pulcher										
Ophidion scrippae										
Mustelus henlei										

Appendix E. (continued)

Species	09 jun 95 0830-1230 No.	Wt.	27 jun 95 0800-1331 No.	Wt.	10 oct 95 0700-1530 No.	Wt.	25 oct 95 0900-1600 No.	Wt.	16 nov 95 0800-1300 No.	Wt.
Balistes polylepis										
Porichthys myriaster	1	0.312								
Pleuronichthys verticalis										
Chilara taylori										
Paralabrax maculatofasciata										
Hypsoblennius jenkinsi										
Torpedo californica										
Squalis acanthias										
Xystreurys liolepis										
Hexagrammos decagrammus										
Syngnathus californiensis										
Cephaloscyllium ventriosum										
Roncador stearnsii										
Hippoglossina stomata										
Pleuronichthys coenosus										
Strongylura exilis										
Syngnathus leptorhynchus										
Gibbonsia metzi										
Micrometrus minimus										
Clinocottus analis										
Citharichthys stigmaeus										
Syngnathus sp.										
Survey totals	8950	519.472	2302	80.254	5856	773.105	3986	229.523	569	36.865
Total Species	40		20		25		21		22	

Appendix E. (continued)

Species	Station Totals No.	Station Totals Wt.
Trachurus symmetricus	69195	2258.84
Seriphus politus	38479	1416.74
Atherinops affinis	24029	1036.63
Atherinopsis californiensis	16820	1817.94
Engraulis mordax	14561	104.59
Sardinops sagax	10500	543.29
Genyonemus lineatus	9063	241.46
Xenistius californiensis	7770	222.26
Umbrina roncador	5471	748.59
Hyperprosopon argenteum	3320	191.46
Anisotremus davidsonii	3179	1565.38
Scomber japonicus	3168	276.91
Paralabrax nebulifer	2296	972.30
Chromis punctipinnis	1714	183.12
Paralabrax clathratus	1322	470.25
Leuresthes tenuis	1193	33.89
Porichthys notatus	880	122.80
Phanerodon furcatus	526	46.76
Cheilotrema saturnum	468	55.82
Peprilus simillimus	449	29.65
Medialuna californiensis	236	69.77
Embiotoca jacksoni	219	34.75
Rhacochilus toxotes	214	56.51
Scorpaena guttata	201	43.78
Oxyjulis californica	191	8.35
Damalichthys vacca	179	37.39
Cymatogaster aggregata	173	6.32
Girella nigricans	156	105.43
Myliobatis californica	150	386.48
Atractoscion nobilis	149	34.36
Sebastes paucispinis	136	4.05
Urolophus halleri	127	77.31
Halichoeres semicinctus	121	30.53
Menticirrhus undulatus	120	21.31
Pleuronichthys ritteri	109	11.84
Sphyraena argentea	93	30.24
Platyrhinoidis triseriata	74	40.47
Mustelus californicus	67	101.66
Brachyistius frenatus	63	2.08
Heterostichus rostratus	56	2.93
Hypsoblennius gilberti	55	0.18
Scorpaenichthys marmoratus	43	16.31
Paralichthys californicus	37	23.34
Rhinobatus productus	31	77.83
Hypsurus caryi	27	2.41
Hermosilla azurea	25	12.05
Sebastes auriculatus	24	8.60
Sebastes rastrelliger	21	6.07
Anchoa compressa	20	0.36
Hypsoblennius, sp.	19	0.06
Triakis semifaciata	13	77.92
Hypsopsetta guttulata	10	2.85
Heterodontus francisci	9	18.78
Sebastes serranoides	8	1.31
Semicossyphus pulcher	7	2.56
Ophidion scrippae	7	0.42
Mustelus henlei	5	10.22

Appendix E. (continued)

Species	Station Totals No.	Wt.
Balistes polylepis	4	9.14
Porichthys myriaster	4	1.50
Pleuronichthys verticalis	4	0.44
Chilara taylori	4	0.27
Paralabrax maculatofasciata	3	1.61
Hypsoblennius jenkinsi	3	0.02
Torpedo californica	2	17.72
Squalis acanthias	2	2.20
Xystreurys liolepis	2	0.70
Hexagrammos decagrammus	2	0.10
Syngnathus californiensis	2	0.01
Cephaloscyllium ventriosum	1	2.85
Roncador stearnsii	1	1.40
Hippoglossina stomata	1	0.45
Pleuronichthys coenosus	1	0.37
Strongylura exilis	1	0.25
Syngnathus leptorhynchus	1	0.05
Gibbonsia metzi	1	0.05
Micrometrus minimus	1	0.04
Clinocottus analis	1	0.01
Citharichthys stigmaeus	1	0.01
Syngnathus sp.	1	0.01
Survey totals	217636	13744.752
Total Species	79	

APPENDIX F

NUMBER OF DAYS, TOTAL AND MEAN DAILY FLOW, SEA SURFACE TEMPERATURE, MEAN WAVE HEIGHT, AND DAYS OF RAIN BETWEEN HEAT TREATMENTS, BY HEAT TREATMENT

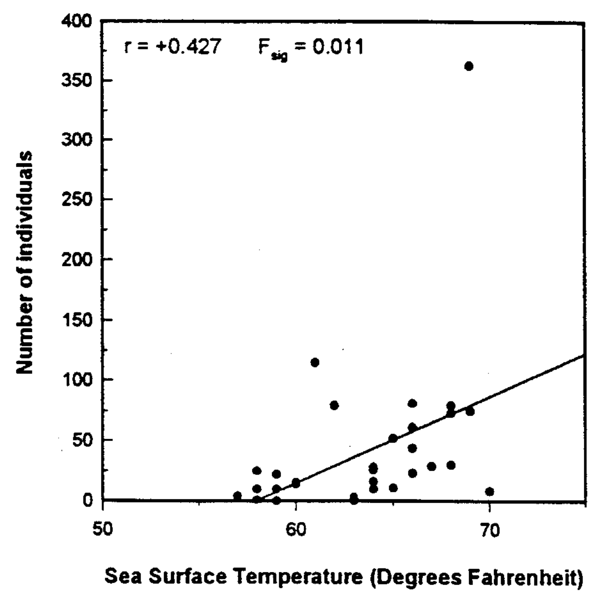
Appendix F. Number of days, total and mean daily flow, sea surface temperature, mean wave height, and days of rain between heat treatments, by heat treatment.

HT Date	Number of Days Between Heat Treatments	Total Flow (millions of gallons)	Mean Daily Flow (mgd)	SMB sea surface temp (°F)	Mean Wave Ht. (ft)	Days of Rain
08-Nov-89	42	8852	210.76	63		
16-Jan-90	69	11057	160.24	59		
17-Mar-90	60	13607	226.79	58		
26-Apr-90	40	7594	189.85	63		
20-Jun-90	55	17172	312.22	69		
29-Aug-90	70	25891	369.87	69		
05-Dec-90	98	32664	333.31	61		
23-Jan-91	49	15139	308.96	58		
28-Mar-91	64	15513	242.38	58		
28-May-91	61	16518	270.78	60		
10-Jul-91	43	13054	303.57	66		
28-Aug-91	49	17369	354.46	68		
23-Oct-91	56	20110	359.11	66		
31-Jan-92	100	23031	230.31	60		
29-Apr-92	89	24499	275.27	70	2.8	1
08-Jul-92	70	23671	338.16	68	1.9	0
03-Sep-92	57	21704	380.76	66	2.1	2
14-Oct-92	41	14098	343.85	67	2.5	0
13-Jan-93	91	32283	354.76	58	2.5	11
20-Apr-93	97	19680	202.89	63	3.2	10
14-May-93	24	4244	176.82	63	2.9	0
19-Aug-93	97	28120	289.90	66	2.3	1
09-Nov-93	82	28498	347.53	65	1.9	0
22-Dec-93	43	16580	385.57	59	3.0	0
24-Feb-94	64	24477	382.45	57	3.6	1
27-Apr-94	62	24074	388.29	58	2.8	3
07-Jul-94	71	24420	343.94	64	2.2	1
15-Sep-94	70	25861	369.45	68	2.4	0
27-Oct-94	42	9898	235.66	64	2.1	0
02-Mar-95	126	41066	325.92	59	3.3	16
09-Jun-95	99	28132	284.16	64	2.5	5
27-Jun-95	18	4205	233.60	65	3.1	0
10-Oct-95	105	40086	381.78	62	2.5	1
25-Oct-95	15	5882	392.12	64	2.1	0
16-Nov-95	22	7784	353.82	63	1.8	2

APPENDIX G
CORRELATION CALCULATIONS AND GRAPHS

Appendix G-1. Correlations of sea surface temperature (SST) between heat treatments with 20 parameters.

Paralabrax clathratus Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.42668104
R Square	0.18205671
Adjusted R Square	0.15727055
Standard Error	58.8443279
Observations	35

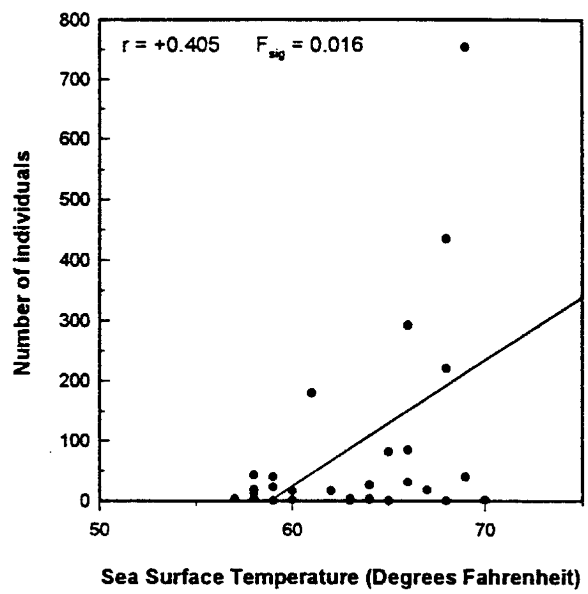
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	25433.53019	25433.53019	7.34509523	0.010584793
Residual	33	114267.6127	3462.654929		
Total	34	139701.1429			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-416.95531	168.0579909	-2.481020421	0.01820718	-758.8721316	-75.038483
x1	7.19739292	2.655684613	2.710183615	0.01046077	1.79435767	12.6004282

Appendix G-1. (continued)

Anisotremus davidsonii Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.40534182
R Square	0.16430199
Adjusted R Square	0.13897781
Standard Error	182.46194
Observations	35

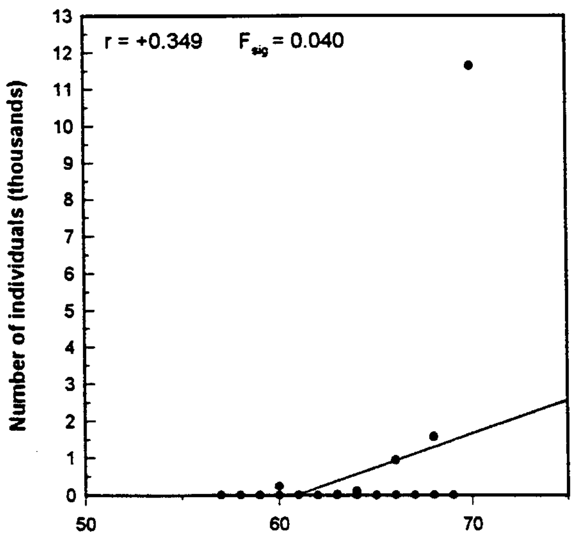
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	215999.1117	215999.1117	6.48794846	0.01570693
Residual	33	1098647.86	33292.35938		
Total	34	1314646.971			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1234.1796	521.1069282	-2.368380801	0.02369195	-2294.380502	-173.97879
x1	20.9748021	8.234631651	2.547145158	0.01555503	4.221304796	37.7282995

Appendix G-1. (continued)

Engraulis mordax Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.34871375
R Square	0.12160128
Adjusted R Square	0.09498314
Standard Error	1881.67672
Observations	35

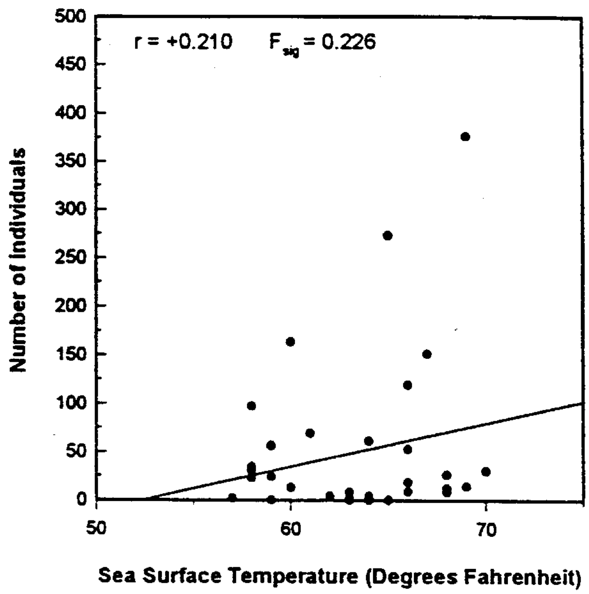
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	16175228.18	16175228.18	4.56836074	0.040068657
Residual	33	116843340.6	3540707.29		
Total	34	133018568.7			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-11050.24	5374.023643	-2.056232189	0.04750119	-21983.78238	-116.69842
x1	181.508554	84.92135258	2.137372392	0.03984352	8.734626591	354.282482

Appendix G-1. (continued)

Chromis punctipinnis Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.20989457
R Square	0.04405573
Adjusted R Square	0.01508772
Standard Error	80.9559521
Observations	35

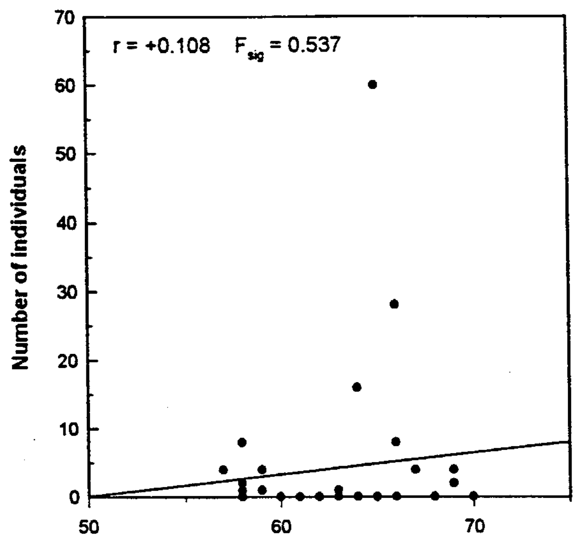
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	9967.387397	9967.387397	1.52084085	0.226204894
Residual	33	216277.584	6553.866183		
Total	34	226244.9714			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-235.66027	231.2082598	-1.019255391	0.31527997	-706.0573798	234.736849
x1	4.50570298	3.653597278	1.233223762	0.22595069	-2.927602466	11.9390084

Appendix G-1. (continued)

Atractoscion nobilis Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.108
R Square	0.012
Adjusted R Square	-0.018
Standard Error	11.251
Observations	35.000

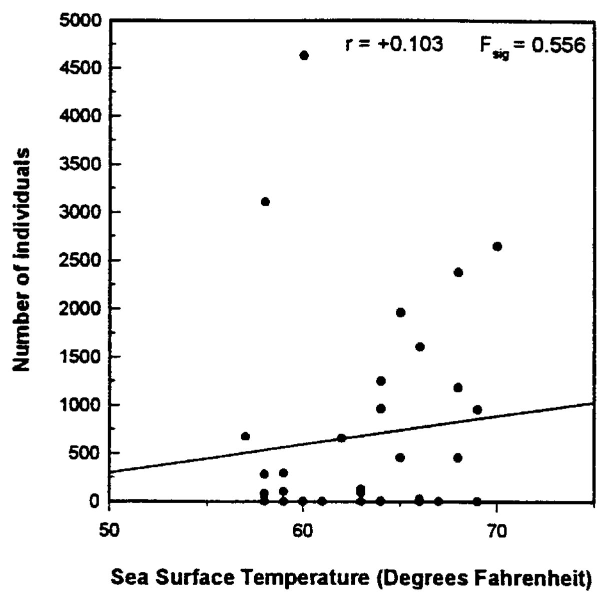
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1.000	49.223	49.223	0.389	0.537
Residual	33.000	4177.463	126.590		
Total	34.000	4226.686			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	-15.745	32.133	-0.490	0.627	-81.120	49.631
x1	0.317	0.508	0.624	0.537	-0.716	1.350

Appendix G-1. (continued)

Atherinops affinis Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.10296985
R Square	0.01060279
Adjusted R Square	-0.0193789
Standard Error	1095.54275
Observations	35

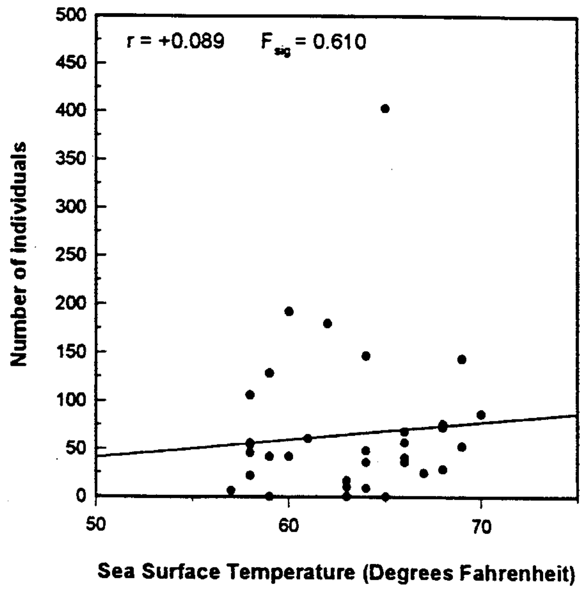
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	424445.6188	424445.6188	0.35364164	0.556114681
Residual	33	39607059.07	1200213.911		
Total	34	40031504.69			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1170.8493	3128.843841	-0.374211497	0.7105707	-7536.535042	5194.83637
x1	29.4024092	49.44259063	0.594677764	0.55599601	-71.18937751	129.994196

Appendix G-1. (continued)

Paralabrax nebulifer Abundance vs. Sea Surface Temperature



Regression Statistics

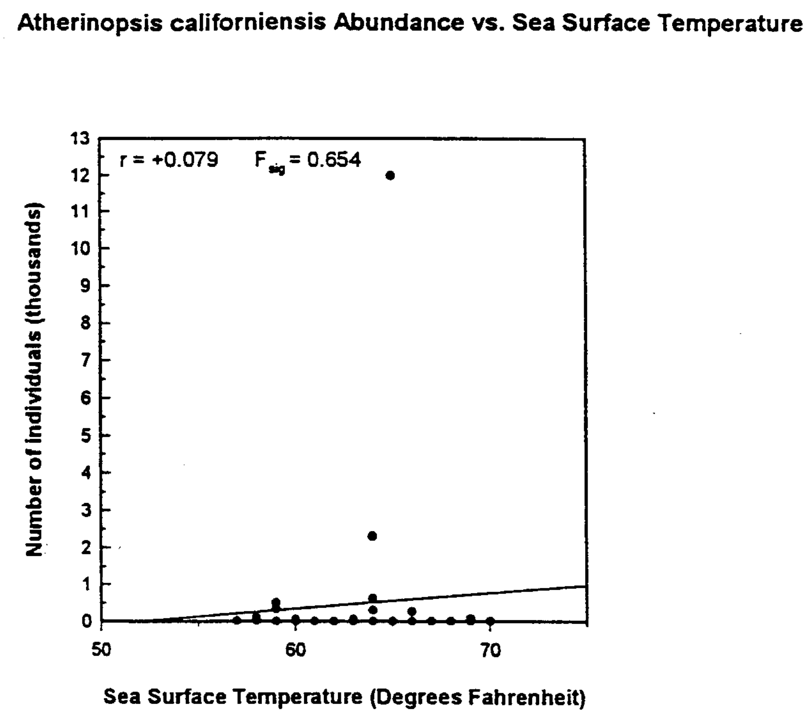
Multiple R	0.08923242
R Square	0.00796242
Adjusted R Square	-0.0220993
Standard Error	78.5187549
Observations	35

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	1632.969076	1632.969076	0.26486901	0.610224636
Residual	33	203451.4309	6165.194876		
Total	34	205084.4			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-49.607716	224.2476831	-0.221218413	0.82624559	-505.8434198	406.627987
x1	1.82373138	3.543604908	0.514654265	0.61012424	-5.385792732	9.03325549

Appendix G-1. (continued)



Regression Statistics

Multiple R	0.07853776
R Square	0.00616818
Adjusted R Square	-0.0239479
Standard Error	2066.00656
Observations	35

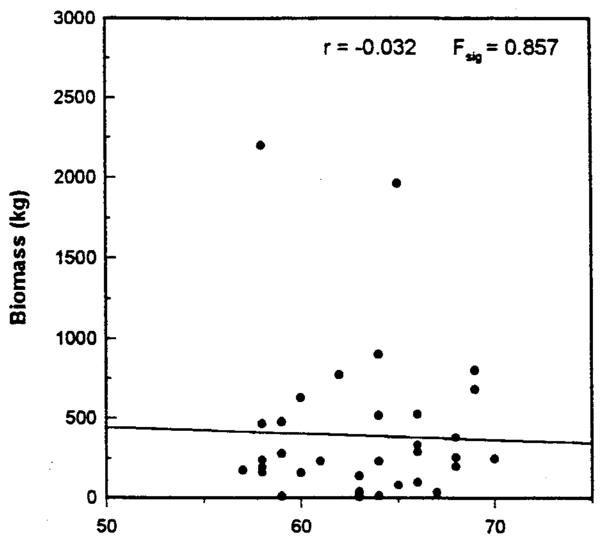
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	874221.4738	874221.4738	0.20481326	0.653824736
Residual	33	140856643.1	4268383.124		
Total	34	141730864.6			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-2185.0798	5900.465254	-0.370323303	0.7134387	-14189.67612	9819.51656
x1	42.197102	93.24028391	0.452562993	0.65373804	-147.5018324	231.896036

Appendix G-1. (continued)

Biomass vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.03161357
R Square	0.00099942
Adjusted R Square	-0.0292733
Standard Error	495.072305
Observations	35

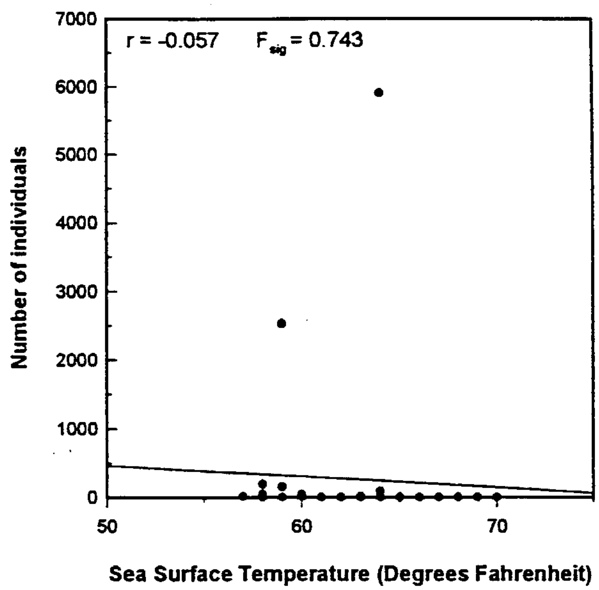
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	8091.564852	8091.564852	0.03301378	0.856932047
Residual	33	8088187.374	245096.5871		
Total	34	8096278.939			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	649.16065	1413.914643	0.459122941	0.6490678	-2227.472601	3525.7939
x1	-4.0596459	22.34295044	-0.181696946	0.85689949	-49.51675635	41.3974646

Appendix G-1. (continued)

Genyonemus lineatus Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.057
R Square	0.003
Adjusted R Square	-0.027
Standard Error	1084.435
Observations	35.000

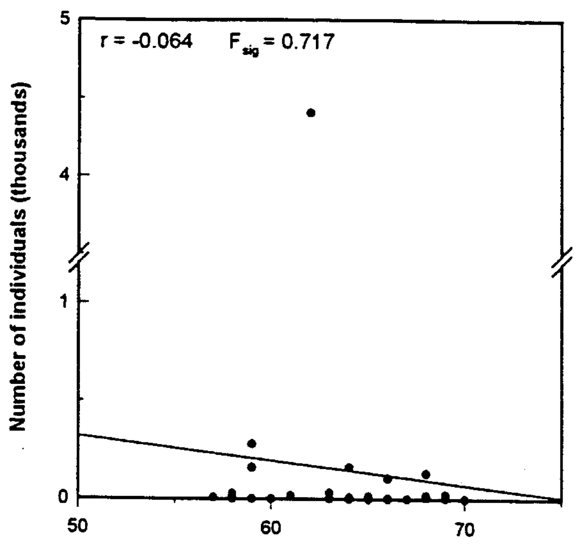
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1.000	128524.157	128524.157	0.109	0.743
Residual	33.000	38807991.729	1175999.749		
Total	34.000	38936515.886			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	1281.023	3097.121	0.414	0.682	-5020.122	7582.168
x1	-16.179	48.941	-0.331	0.743	-115.751	83.392

Appendix G-1. (continued)

Umbrina roncador Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.06350472
R Square	0.00403285
Adjusted R Square	-0.026148
Standard Error	751.495772
Observations	35

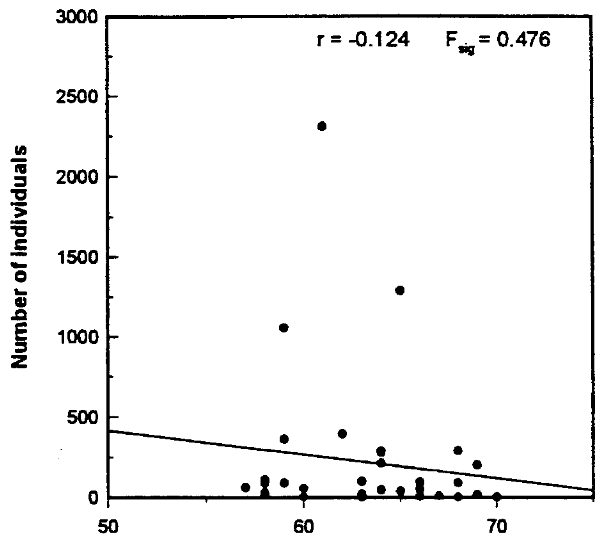
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	75463.0016	75463.0016	0.13362293	0.717037595
Residual	33	18636614.54	564745.8952		
Total	34	18712077.54			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	939.490747	2146.253921	0.437735134	0.66434659	-3427.09915	5306.08064
x1	-12.397637	33.91551621	-0.365544704	0.71696928	-81.3993286	56.6040539

Appendix G-1. (continued)

Xenistius californiensis Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.12449108
R Square	0.01549803
Adjusted R Square	-0.01433354
Standard Error	459.288013
Observations	35

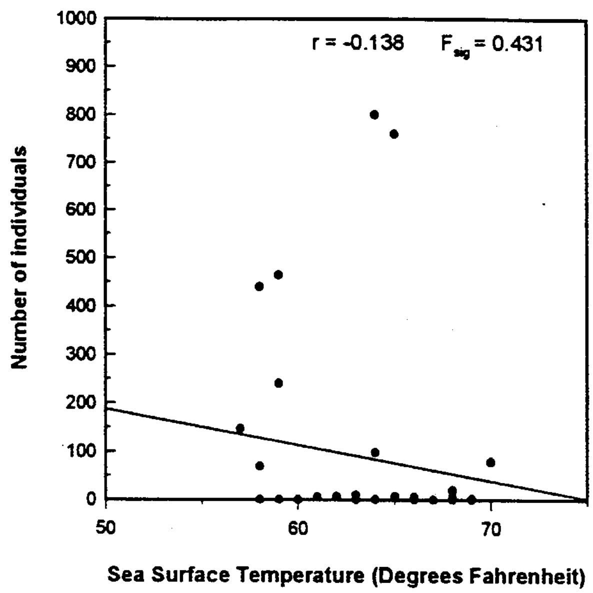
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	109583.2097	109583.2097	0.51948594	0.476136212
Residual	33	6961200.79	210945.4785		
Total	34	7070784			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1165.76659	1311.715561	0.88873428	0.38039069	-1502.940906	3834.47408
x1	-14.93977	20.72798094	-0.720753729	0.47598782	-57.1111973	27.2316582

Appendix G-1. (continued)

Scomber japonicus Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.13736232
R Square	0.01886841
Adjusted R Square	-0.0108629
Standard Error	207.122508
Observations	35

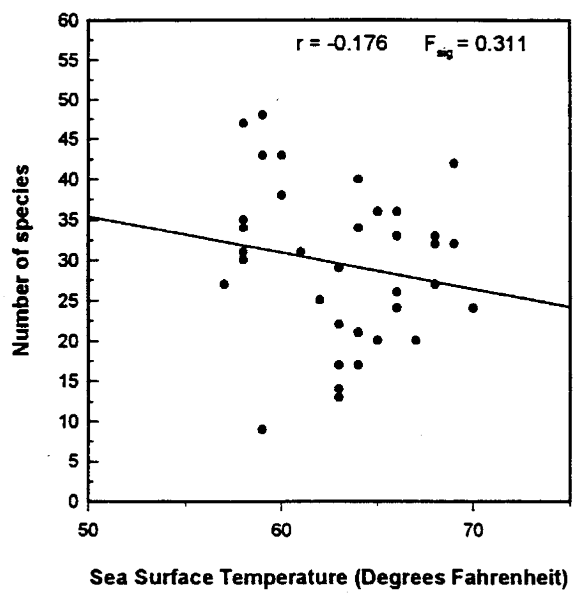
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	27225.54098	27225.54098	0.63463194	0.431355637
Residual	33	1415691.202	42899.73339		
Total	34	1442916.743			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	560.928946	591.5369214	0.948256863	0.34969036	-642.5629243	1764.42082
x1	-7.4466364	9.347579915	-0.796637897	0.43118922	-26.46444582	11.571173

Appendix G-1. (continued)

Number of Fish Species vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.17614289
R Square	0.03102632
Adjusted R Square	0.00166348
Standard Error	9.70658537
Observations	35

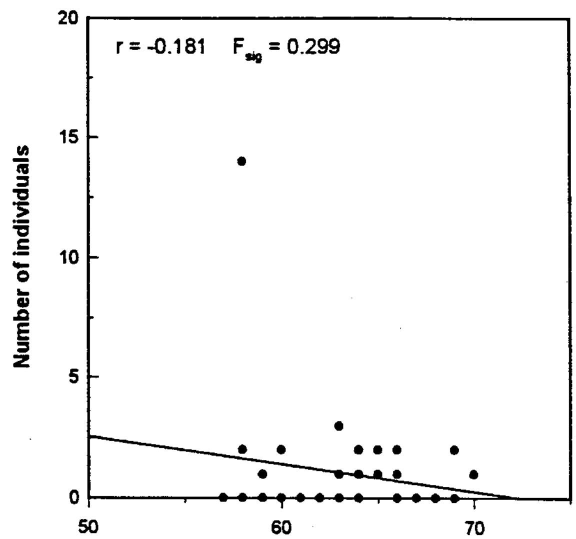
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	99.55547353	99.55547353	1.0566525	0.311455884
Residual	33	3109.187384	94.2177995		
Total	34	3208.742857			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	57.9605447	27.72177528	2.09079484	0.04409376	1.560124104	114.360965
x1	-0.4503026	0.438064811	-1.02793604	0.31123768	-1.341552873	0.44094766

Appendix G-1. (continued)

Paralichthys californicus Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.181
R Square	0.033
Adjusted R Square	0.003
Standard Error	2.408
Observations	35.000

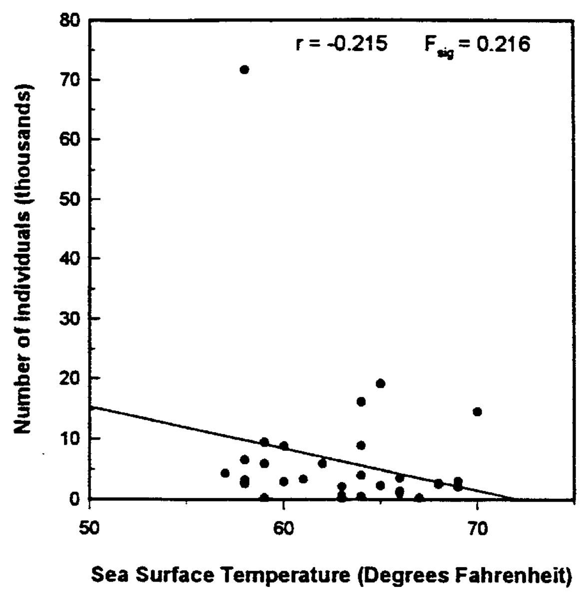
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1.000	6.466	6.466	1.115	0.299
Residual	33.000	191.420	5.801		
Total	34.000	197.886			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	8.307	6.878	1.208	0.236	-5.688	22.301
x1	-0.115	0.109	-1.056	0.299	-0.336	0.106

Appendix G-1. (continued)

Total Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.21451562
R Square	0.04601695
Adjusted R Square	0.01710837
Standard Error	12154.252
Observations	35

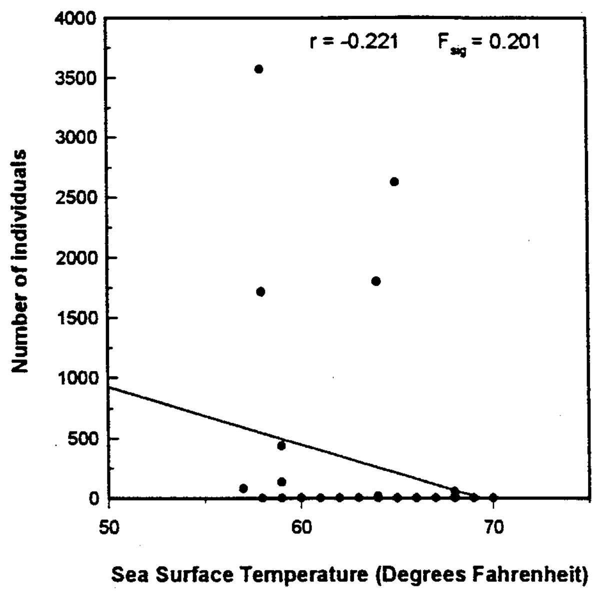
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	235151408.6	235151408.6	1.59180956	0.215913216
Residual	33	4874952797	147725842.3		
Total	34	5110104206			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	49936.8135	34712.25262	1.438593286	0.15940822	-20685.8514	120559.478
x1	-692.06308	548.5296752	-1.261669356	0.21565513	-1808.055982	423.929818

Appendix G-1. (continued)

Sardinops sagax Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.221
R Square	0.049
Adjusted R Square	0.020
Standard Error	812.563
Observations	35.000

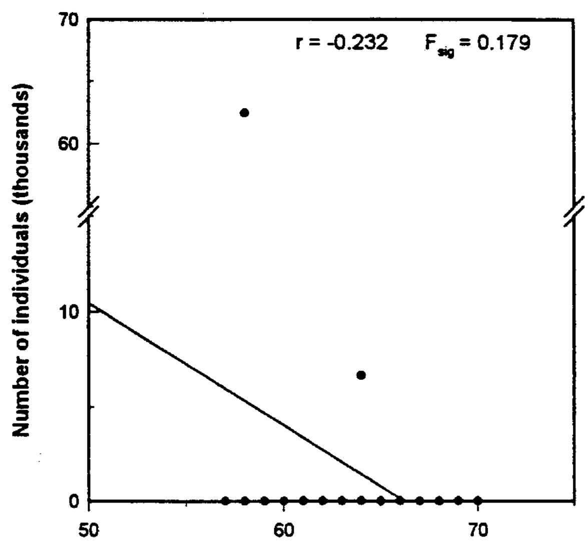
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1.000	1122610.191	1122610.191	1.700	0.201
Residual	33.000	21788547.809	660259.025		
Total	34.000	22911158.000			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	3320.696	2320.661	1.431	0.162	-1400.728	8042.121
x1	-47.817	36.672	-1.304	0.201	-122.426	26.791

Appendix G-1. (continued)

Trachurus symmetricus Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.232
R Square	0.054
Adjusted R Square	0.025
Standard Error	10442.534
Observations	35.000

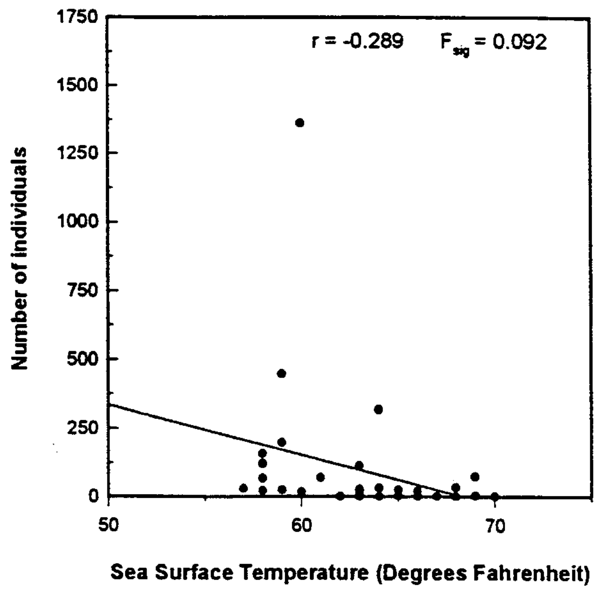
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1.000	205158354.974	205158354.974	1.881	0.179
Residual	33.000	3598535195.026	109046521.061		
Total	34.000	3803693550.000			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	42812.436	29823.628	1.436	0.160	-17864.239	103489.110
x1	-646.423	471.279	-1.372	0.179	-1605.247	312.402

Appendix G-1. (continued)

Hyperprosopon argenteum Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.289
R Square	0.083
Adjusted R Square	0.056
Standard Error	233.821
Observations	35.000

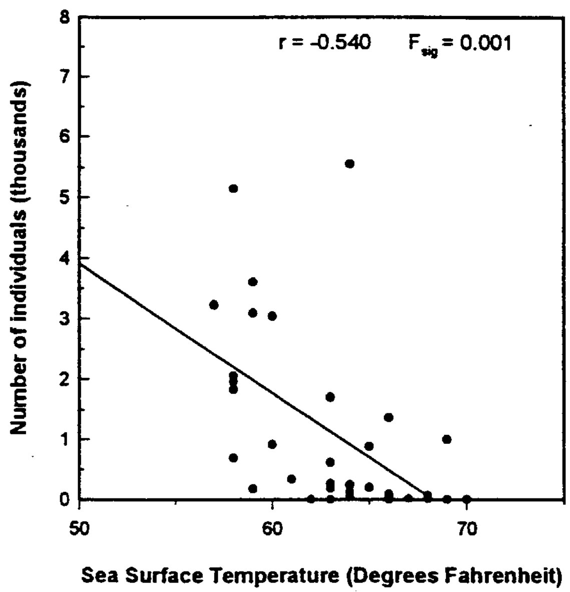
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1.000	164288.434	164288.434	3.005	0.092
Residual	33.000	1804179.852	54672.117		
Total	34.000	1968468.286			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	1250.427	667.786	1.872	0.070	-108.196	2609.049
x1	-18.293	10.552	-1.733	0.092	-39.762	3.177

Appendix G-1. (continued)

Seriphus politus Abundance vs. Sea Surface Temperature



Regression Statistics

Multiple R	0.53988384
R Square	0.29147456
Adjusted R Square	0.27000409
Standard Error	1285.79456
Observations	35

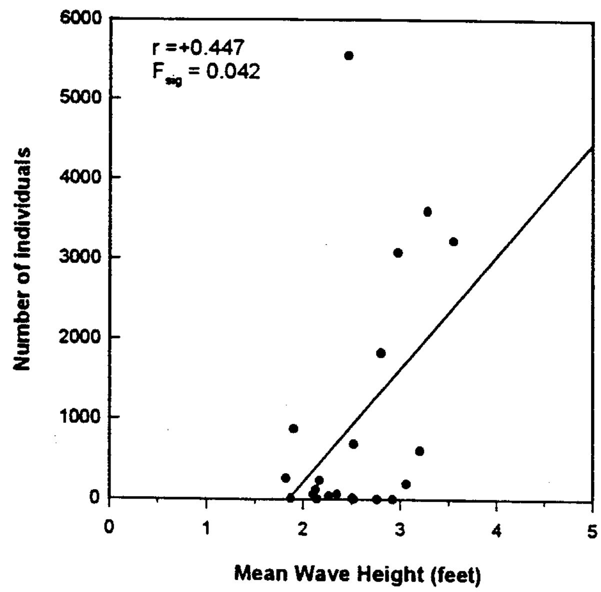
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	22444105.84	22444105.84	13.5756033	0.000815876
Residual	33	54557832.56	1653267.653		
Total	34	77001938.4			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	14605.9286	3672.198464	3.977434428	0.00034544	7134.778724	22077.0785
x1	-213.80755	58.02878461	-3.684508559	0.0007917	-331.8680971	-95.74701

Appendix G-2. Correlations of mean wave height between heat treatments with 20 parameters.

Seriphus politus Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.447
R Square	0.199
Adjusted R Square	0.157
Standard Error	1435.103
Observations	21.000

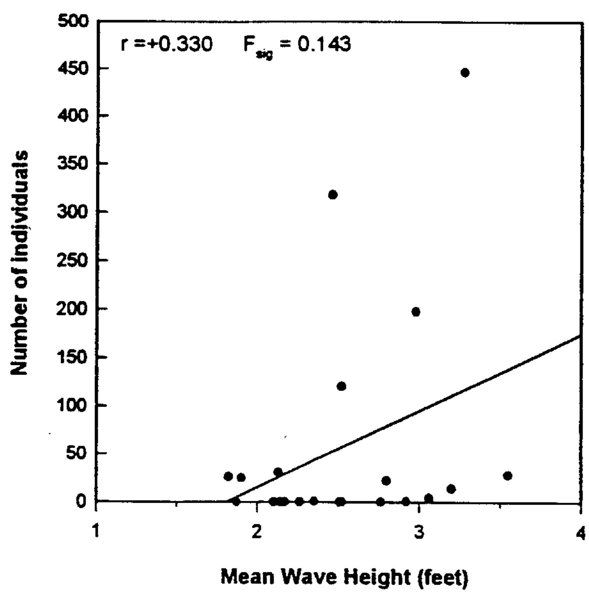
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	9745830.215	9745830.215	4.732	0.042
Residual	19.000	39130871.594	2059519.558		
Total	20.000	48876701.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-2607.605	1677.376	-1.555	0.136	-6118.395	903.185
x1	1412.359	649.260	2.175	0.042	53.442	2771.275

Appendix G-2. (continued)

Hyperprosopon argenteum Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.330
R Square	0.109
Adjusted R Square	0.062
Standard Error	115.751
Observations	21.000

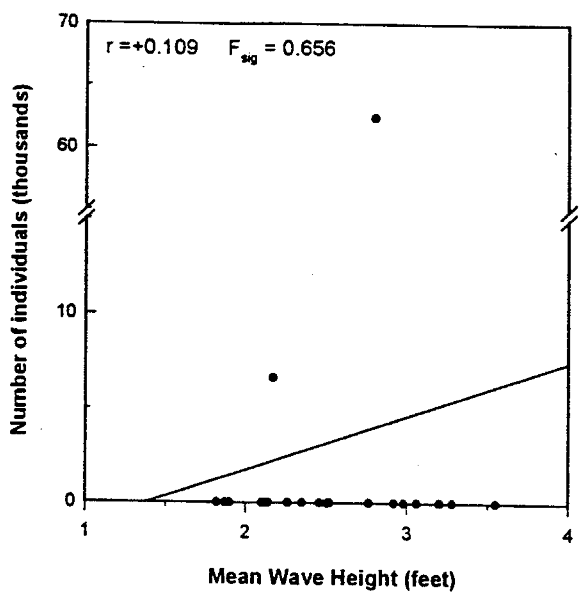
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	31207.283	31207.283	2.329	0.143
Residual	19.000	254567.288	13398.278		
Total	20.000	285774.571			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-143.991	135.292	-1.064	0.300	-427.161	139.178
x1	79.921	52.367	1.526	0.143	-29.685	189.527

Appendix G-2. (continued)

Trachurus symmetricus Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.103
R Square	0.011
Adjusted R Square	-0.041
Standard Error	13903.773
Observations	21.000

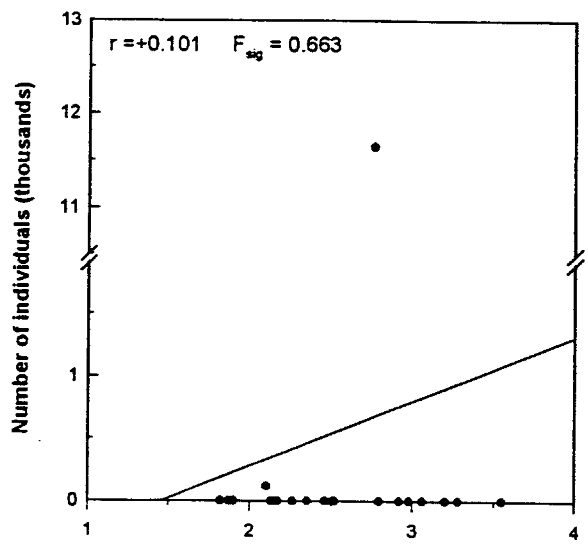
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	39616585.546	39616585.546	0.205	0.656
Residual	19.000	3672983304.263	193314910.751		
Total	20.000	3712599889.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-3933.160	16251.005	-0.242	0.811	-37946.915	30080.595
x1	2847.568	6290.255	0.453	0.656	-10318.090	16013.226

Appendix G-2. (continued)

Engraulis mordax Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.101
R Square	0.010
Adjusted R Square	-0.042
Standard Error	2593.016
Observations	21.000

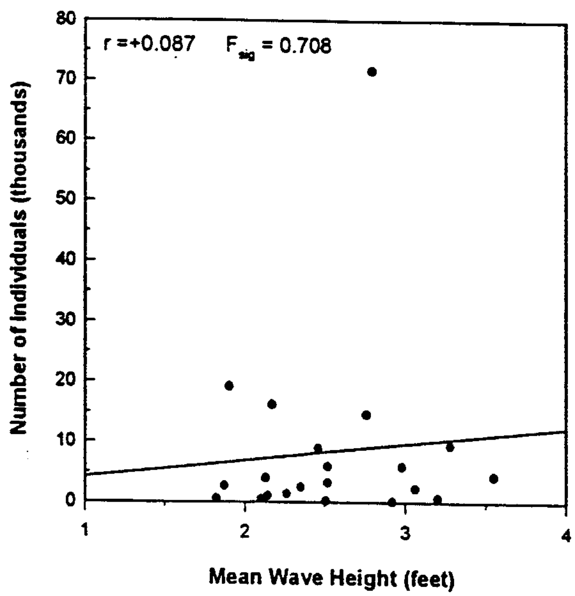
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1314410.903	1314410.903	0.195	0.663
Residual	19.000	127750859.763	6723729.461		
Total	20.000	129065270.667			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-755.797	3030.768	-0.249	0.806	-7099.269	5587.674
x1	518.682	1173.115	0.442	0.663	-1936.677	2974.041

Appendix G-2. (continued)

Total Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

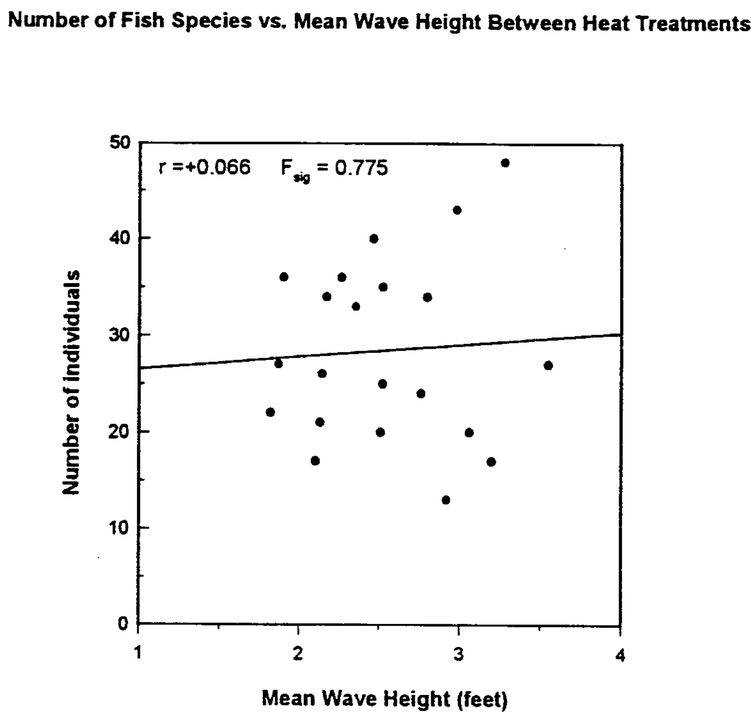
Multiple R	0.087
R Square	0.008
Adjusted R Square	-0.045
Standard Error	15846.762
Observations	21.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	36371857.941	36371857.941	0.145	0.708
Residual	19.000	4771277370.725	251119861.617		
Total	20.000	4807649228.667			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1416.231	18522.008	0.076	0.940	-37350.790	40183.252
x1	2728.464	7169.289	0.381	0.708	-12277.034	17733.963

Appendix G-2. (continued)



Regression Statistics

Multiple R	0.066
R Square	0.004
Adjusted R Square	-0.048
Standard Error	9.574
Observations	21.000

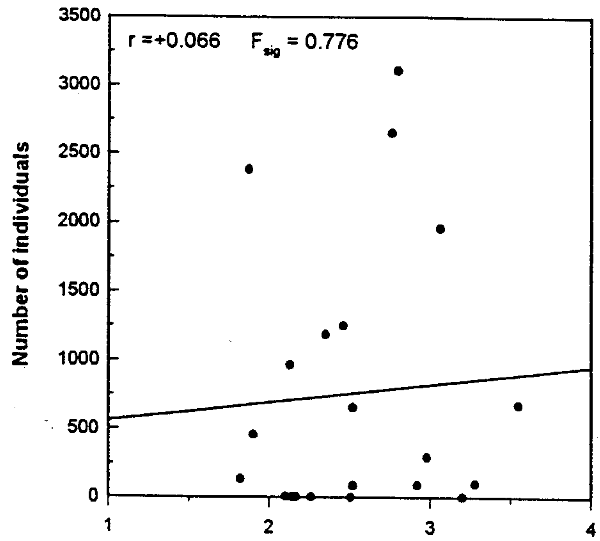
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	7.714	7.714	0.084	0.775
Residual	19.000	1741.524	91.659		
Total	20.000	1749.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	25.287	11.190	2.260	0.035	1.866	48.708
x1	1.257	4.331	0.290	0.775	-7.809	10.322

Appendix G-2. (continued)

Atherinops affinis Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.066
R Square	0.004
Adjusted R Square	-0.048
Standard Error	1001.462
Observations	21.000

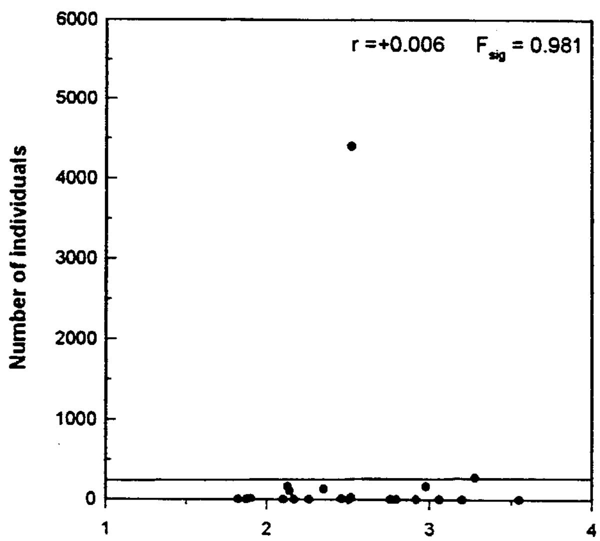
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	83231.994	83231.994	0.083	0.776
Residual	19.000	19055604.006	1002926.527		
Total	20.000	19138836.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	430.725	1170.529	0.368	0.717	-2019.221	2880.671
x1	130.521	453.075	0.288	0.776	-817.776	1078.818

Appendix G-2. (continued)

Umbrina roncador Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.006
R Square	0.000
Adjusted R Square	-0.053
Standard Error	979.059
Observations	21.000

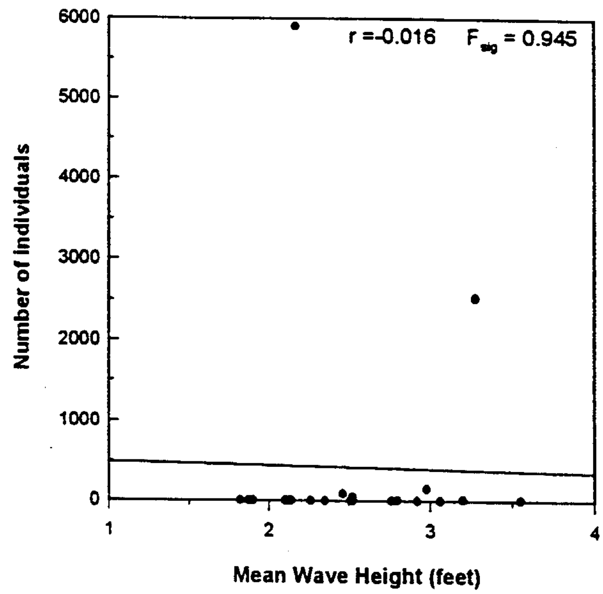
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	552.061	552.061	0.001	0.981
Residual	19.000	18212578.891	958556.784		
Total	20.000	18213130.952			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	226.639	1144.344	0.198	0.845	-2168.500	2621.779
x1	10.630	442.940	0.024	0.981	-916.454	937.713

Appendix G-2. (continued)

Genyonemus lineatus Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.016
R Square	0.000
Adjusted R Square	-0.052
Standard Error	1406.211
Observations	21.000

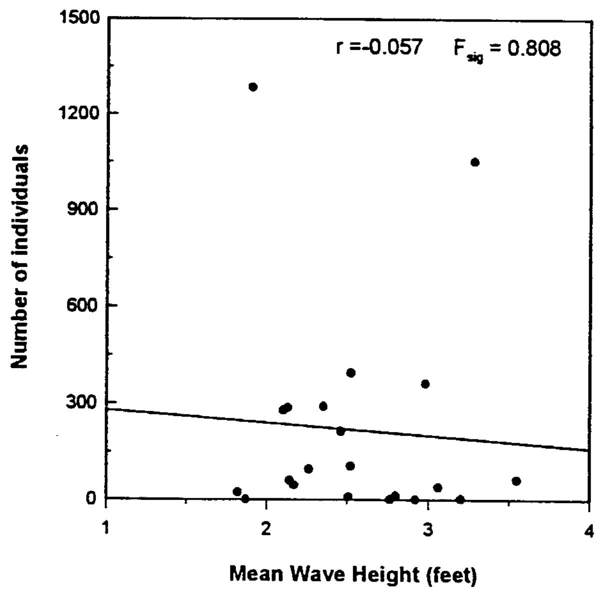
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	9598.613	9598.613	0.005	0.945
Residual	19.000	37571148.340	1977428.860		
Total	20.000	37580746.952			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	530.118	1643.607	0.323	0.750	-2909.992	3970.228
x1	-44.324	636.189	-0.070	0.945	-1375.883	1287.235

Appendix G-2. (continued)

Xenistius californiensis Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.057
R Square	0.003
Adjusted R Square	-0.049
Standard Error	351.435
Observations	21.000

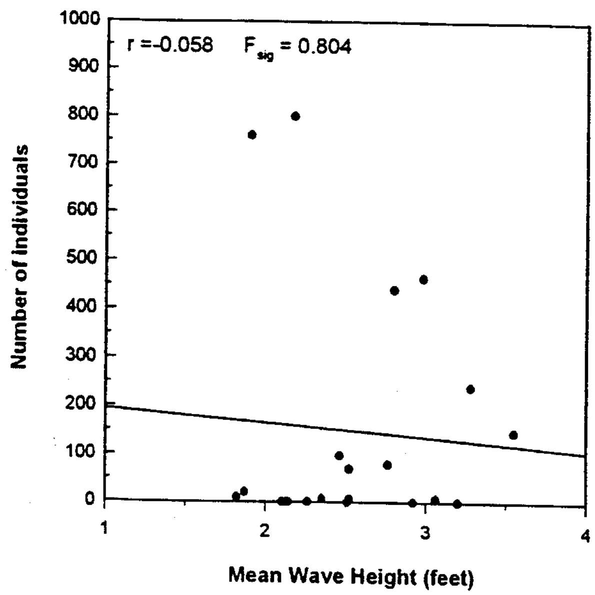
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	7532.080	7532.080	0.061	0.808
Residual	19.000	2346631.158	123506.903		
Total	20.000	2354163.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	319.846	410.765	0.779	0.445	-539.895	1179.587
x1	-39.264	158.994	-0.247	0.807	-372.043	293.515

Appendix G-2. (continued)

Scomber japonicus Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.058
R Square	0.003
Adjusted R Square	-0.049
Standard Error	256.669
Observations	21.000

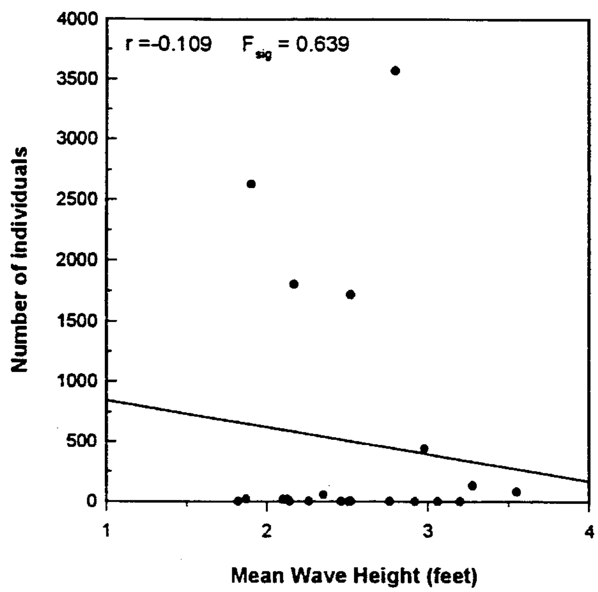
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	4184.428	4184.428	0.064	0.804
Residual	19.000	1251704.810	65879.201		
Total	20.000	1255889.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	224.469	300.000	0.748	0.463	-403.439	852.377
x1	-29.265	116.121	-0.252	0.804	-272.309	213.778

Appendix G-2. (continued)

Sardinops sagax Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.109
R Square	0.012
Adjusted R Square	-0.040
Standard Error	1040.650
Observations	21.000

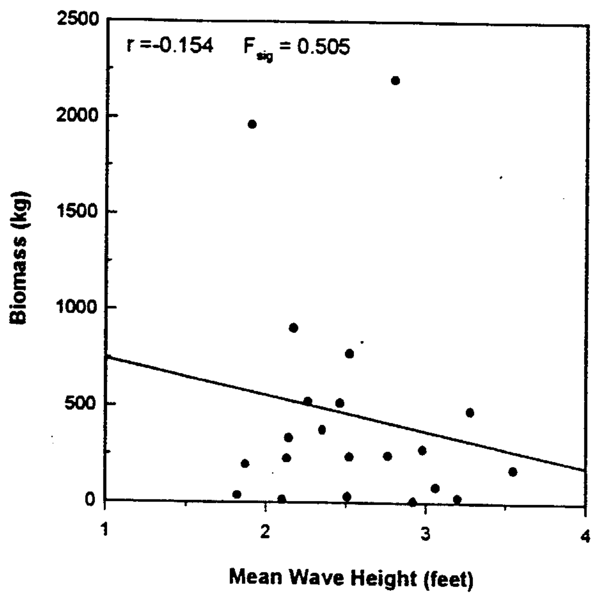
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	246024.414	246024.414	0.227	0.639
Residual	19.000	20576100.824	1082952.675		
Total	20.000	20822125.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1069.027	1216.332	0.879	0.390	-1476.787	3614.841
x1	-224.401	470.804	-0.477	0.639	-1209.806	761.004

Appendix G-2. (continued)

Biomass vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.154
R Square	0.024
Adjusted R Square	-0.028
Standard Error	601.362
Observations	21.000

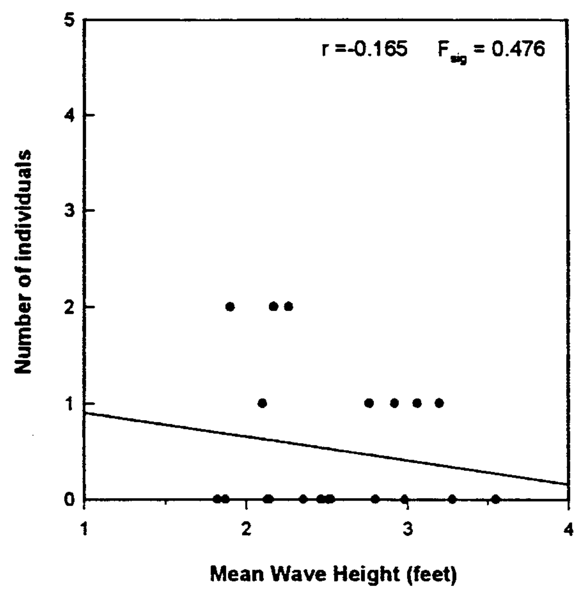
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	167312.530	167312.530	0.463	0.505
Residual	19.000	6871081.174	361635.851		
Total	20.000	7038393.705			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	928.343	702.883	1.321	0.201	-542.810	2399.495
x1	-185.055	272.064	-0.680	0.504	-754.491	384.382

Appendix G-2. (continued)

Paralichthys californicus Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

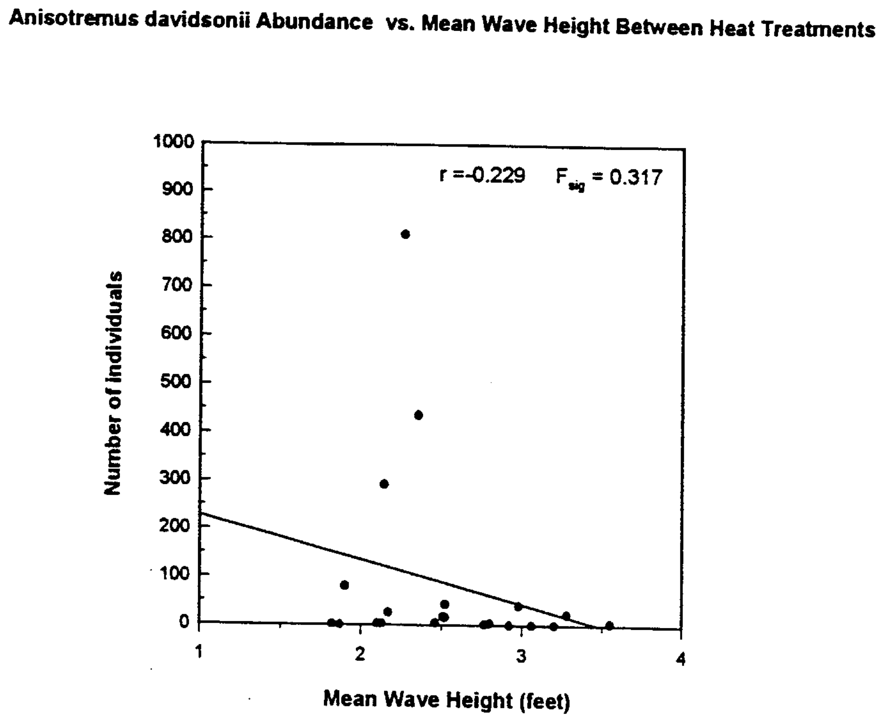
Multiple R	0.165
R Square	0.027
Adjusted R Square	-0.024
Standard Error	0.759
Observations	21.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	0.304	0.304	0.529	0.476
Residual	19.000	10.934	0.575		
Total	20.000	11.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.157	0.887	1.305	0.207	-0.699	3.013
x1	-0.250	0.343	-0.727	0.476	-0.968	0.469

Appendix G-2. (continued)



Regression Statistics

Multiple R	0.229
R Square	0.053
Adjusted R Square	0.003
Standard Error	198.379
Observations	21.000

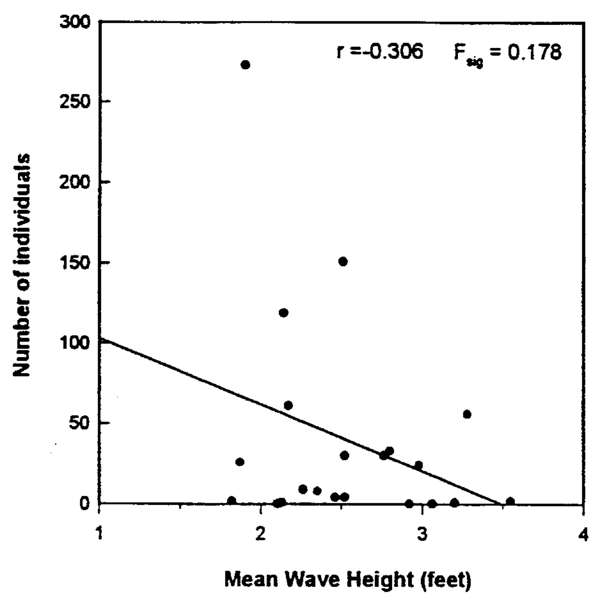
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	41562.719	41562.719	1.056	0.317
Residual	19.000	747727.091	39354.057		
Total	20.000	789289.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	320.192	231.869	1.381	0.183	-165.115	805.499
x1	-92.233	89.749	-1.028	0.316	-280.080	95.614

Appendix G-2. (continued)

Chromis punctipinnis Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.306
R Square	0.094
Adjusted R Square	0.046
Standard Error	65.365
Observations	21.000

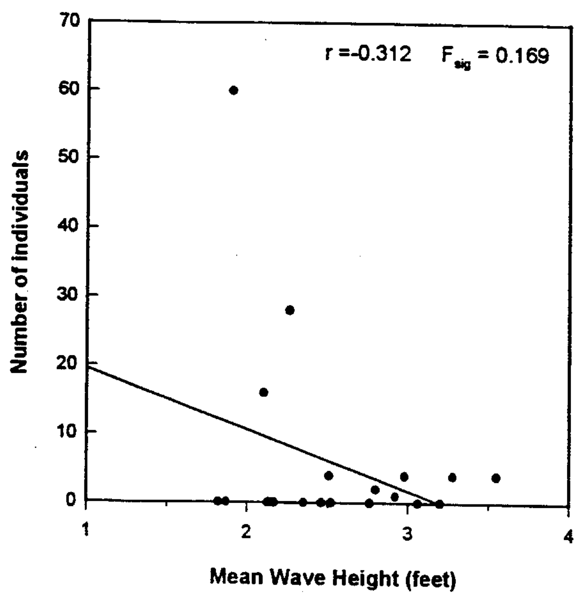
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	8374.967	8374.967	1.960	0.178
Residual	19.000	81179.319	4272.596		
Total	20.000	89554.286			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	144.798	76.400	1.895	0.073	-15.109	304.705
x1	-41.403	29.572	-1.400	0.177	-103.298	20.492

Appendix G-2. (continued)

Atractoscion nobilis Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.312
R Square	0.097
Adjusted R Square	0.050
Standard Error	13.767
Observations	21.000

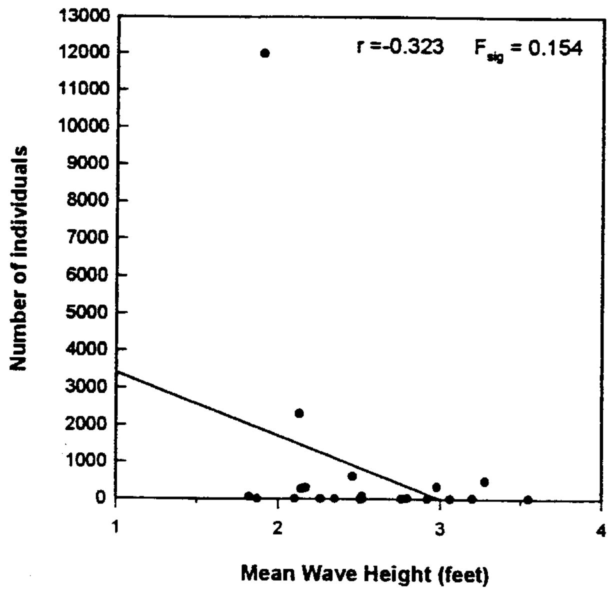
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	387.404	387.404	2.044	0.169
Residual	19.000	3601.168	189.535		
Total	20.000	3988.571			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	28.458	16.091	1.769	0.092	-5.222	62.138
x1	-8.905	6.228	-1.430	0.168	-21.941	4.132

Appendix G-2. (continued)

Atherinopsis californiensis Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

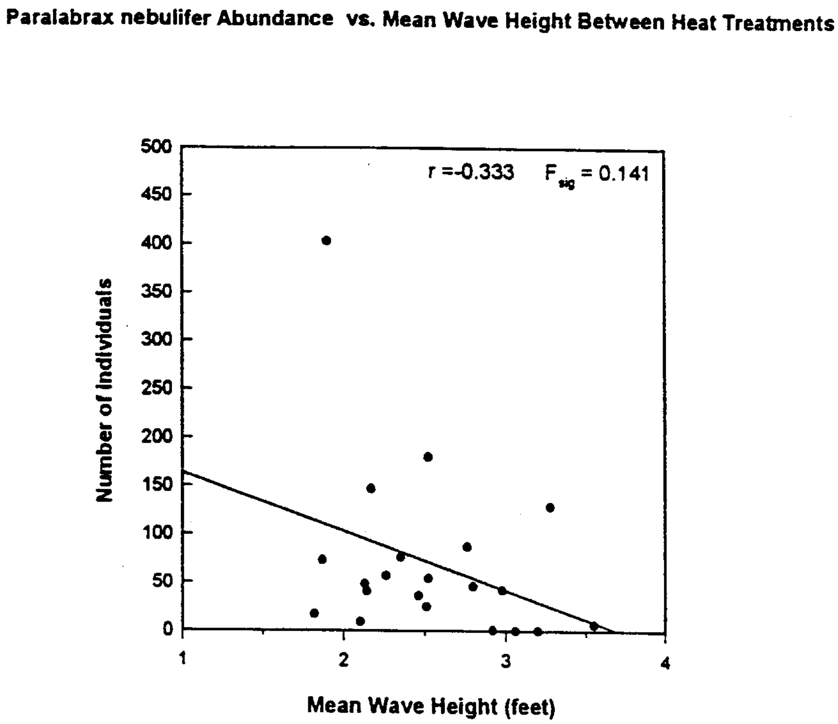
Multiple R	0.323
R Square	0.104
Adjusted R Square	0.057
Standard Error	2540.287
Observations	21.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	14234710.320	14234710.320	2.206	0.154
Residual	19.000	122608135.490	6453059.763		
Total	20.000	136842845.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	5117.388	2969.138	1.724	0.100	-1097.092	11331.867
x1	-1706.907	1149.260	-1.485	0.153	-4112.337	698.523

Appendix G-2. (continued)



Regression Statistics

Multiple R	0.333
R Square	0.111
Adjusted R Square	0.064
Standard Error	87.672
Observations	21.000

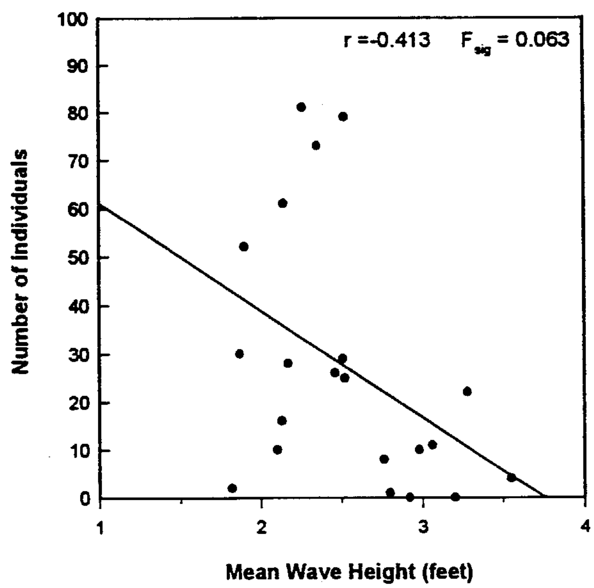
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	18166.058	18166.058	2.363	0.141
Residual	19.000	146042.609	7686.453		
Total	20.000	164208.667			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	225.099	102.473	2.197	0.040	10.620	439.578
x1	-60.977	39.664	-1.537	0.140	-143.995	22.041

Appendix G-2. (continued)

Paralabrax clathratus Abundance vs. Mean Wave Height Between Heat Treatments



Regression Statistics

Multiple R	0.413
R Square	0.170
Adjusted R Square	0.127
Standard Error	24.870
Observations	21.000

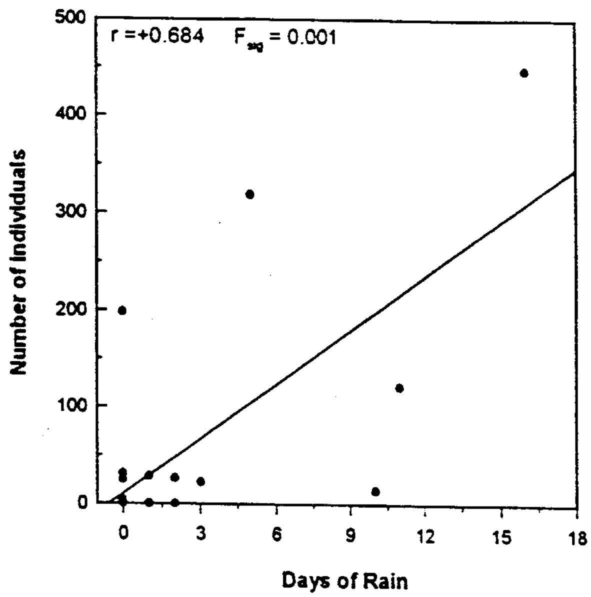
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	2412.990	2412.990	3.901	0.063
Residual	19.000	11751.962	618.524		
Total	20.000	14164.952			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	83.453	29.069	2.871	0.009	22.612	144.295
x1	-22.224	11.252	-1.975	0.062	-45.773	1.326

Appendix G-3. Correlations of number of days of rain between heat treatments with 20 parameters.

Hyperprosopon argenteum Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.684
R Square	0.468
Adjusted R Square	0.441
Standard Error	89.412
Observations	21.000

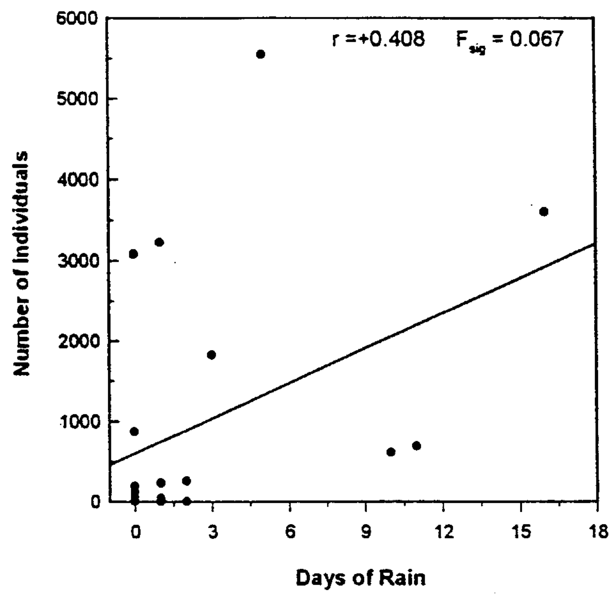
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	133879.304	133879.304	16.746	0.001
Residual	19.000	151895.267	7994.488		
Total	20.000	285774.571			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	10.915	22.758	0.480	0.637	-36.719	58.548
x1	18.644	4.556	4.092	0.001	9.108	28.180

Appendix G-3. (continued)

Seriphus politus Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.408
R Square	0.166
Adjusted R Square	0.122
Standard Error	1464.654
Observations	21.000

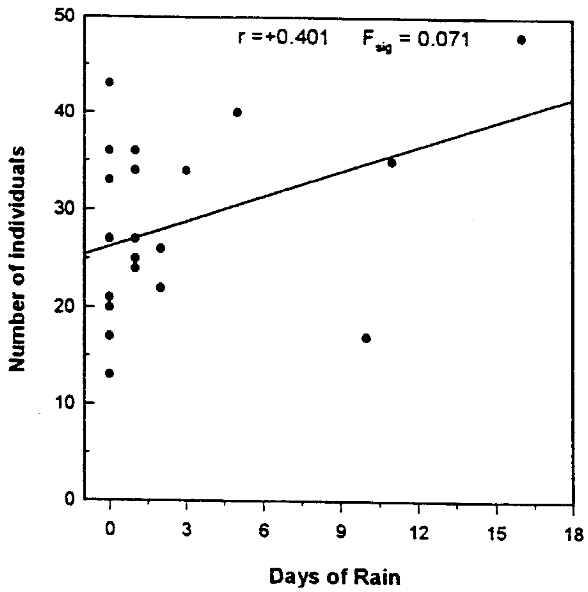
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	8117692.413	8117692.413	3.784	0.067
Residual	19.000	40759009.397	2145211.021		
Total	20.000	48876701.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	603.776	372.804	1.620	0.121	-176.511	1384.064
x1	145.180	74.632	1.945	0.066	-11.027	301.386

Appendix G-3. (continued)

Number of Fish Species vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.401
R Square	0.161
Adjusted R Square	0.117
Standard Error	8.789
Observations	21.000

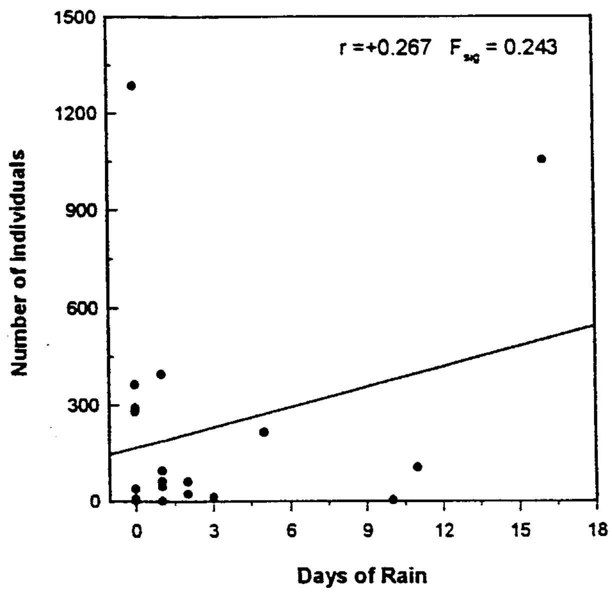
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	281.530	281.530	3.644	0.071
Residual	19.000	1467.709	77.248		
Total	20.000	1749.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	26.278	2.237	11.746	0.000	21.595	30.960
x1	0.855	0.448	1.909	0.071	-0.082	1.792

Appendix G-3. (continued)

Xenistius californiensis Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.267
R Square	0.071
Adjusted R Square	0.022
Standard Error	339.262
Observations	21.000

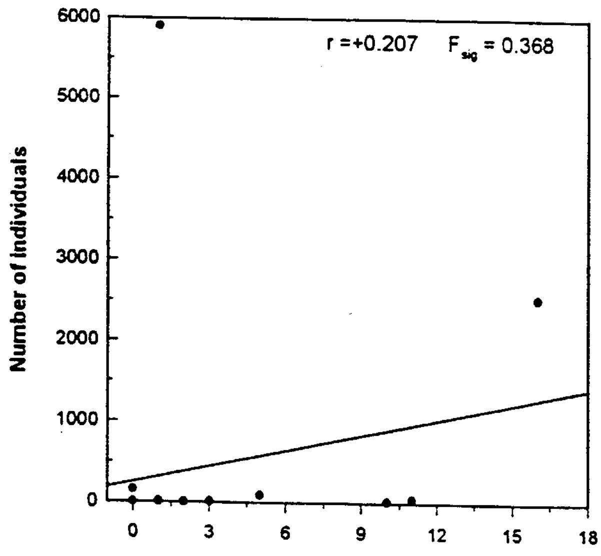
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	167283.752	167283.752	1.453	0.243
Residual	19.000	2186879.486	115098.920		
Total	20.000	2354163.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	166.600	86.354	1.929	0.068	-14.141	347.340
x1	20.841	17.287	1.206	0.242	-15.342	57.023

Appendix G-3. (continued)

Genyonemus lineatus Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.207
R Square	0.043
Adjusted R Square	-0.007
Standard Error	1375.890
Observations	21.000

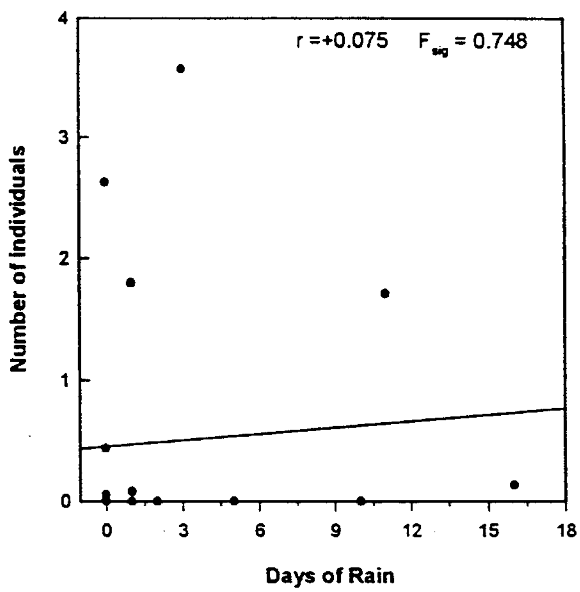
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1612349.882	1612349.882	0.852	0.368
Residual	19.000	35968397.071	1893073.530		
Total	20.000	37580746.952			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	251.242	350.210	0.717	0.481	-481.757	984.241
x1	64.702	70.109	0.923	0.367	-82.037	211.442

Appendix G-3. (continued)

Sardinops sagax Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.075
R Square	0.006
Adjusted R Square	-0.047
Standard Error	1043.940
Observations	21.000

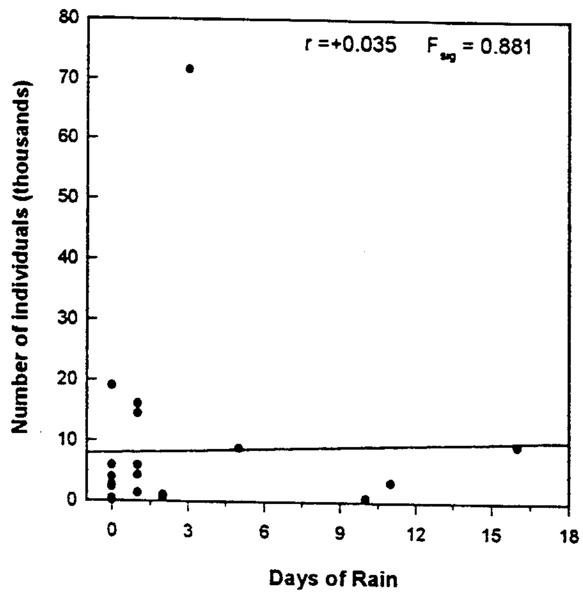
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	115730.540	115730.540	0.106	0.748
Residual	19.000	20706394.698	1089810.247		
Total	20.000	20822125.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	454.902	265.718	1.712	0.102	-101.252	1011.055
x1	17.335	53.194	0.326	0.748	-94.002	128.671

Appendix G-3. (continued)

Total Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.035
R Square	0.001
Adjusted R Square	-0.051
Standard Error	15897.353
Observations	21.000

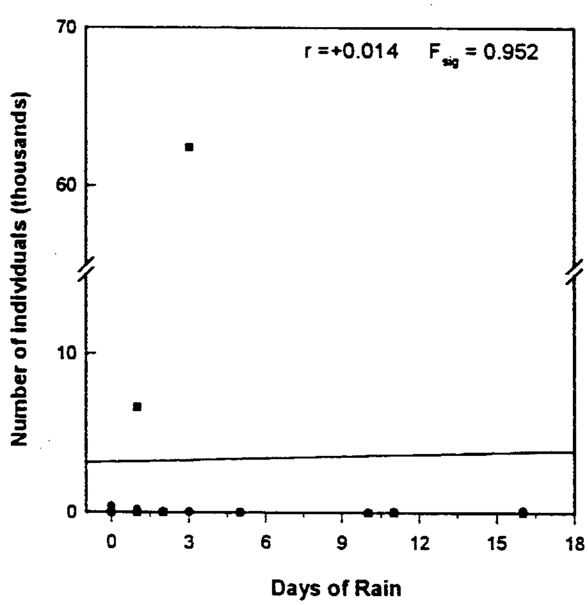
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	5858462.540	5858462.540	0.023	0.881
Residual	19.000	4801790766.127	252725829.796		
Total	20.000	4807649228.667			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	8024.190	4046.410	1.983	0.061	-445.046	16493.426
x1	123.333	810.054	0.152	0.881	-1572.129	1818.796

Appendix G-3. (continued)

Trachurus symmetricus Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.014
R Square	0.000
Adjusted R Square	-0.052
Standard Error	13977.193
Observations	21.000

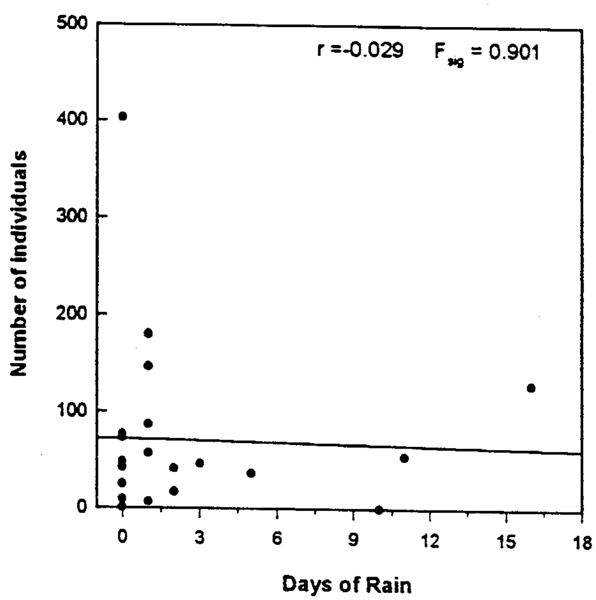
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	723266.350	723266.350	0.004	0.952
Residual	19.000	3711876623.459	195361927.550		
Total	20.000	3712599889.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3182.805	3557.665	0.895	0.382	-4263.475	10629.086
x1	43.335	712.212	0.061	0.952	-1447.342	1534.011

Appendix G-3. (continued)

Paralabrax nebulifer Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.029
R Square	0.001
Adjusted R Square	-0.052
Standard Error	92.927
Observations	21.000

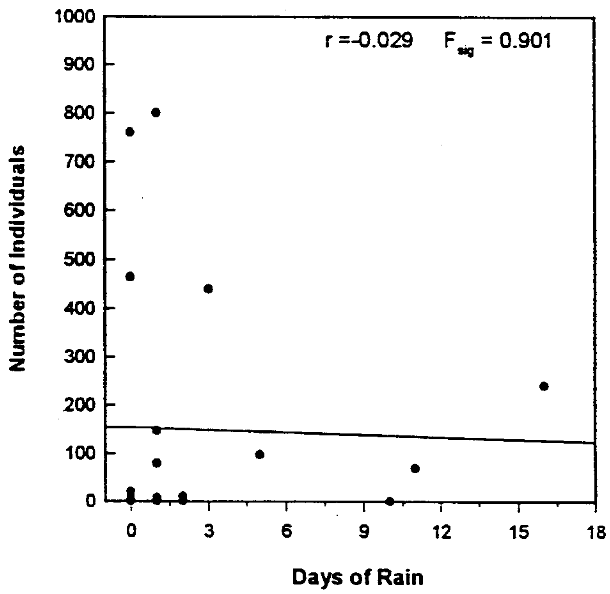
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	136.160	136.160	0.016	0.901
Residual	19.000	164072.507	8635.395		
Total	20.000	164208.667			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	71.862	23.653	3.038	0.006	22.356	121.369
x1	-0.595	4.735	-0.126	0.901	-10.505	9.316

Appendix G-3. (continued)

Scomber japonicus Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.029
R Square	0.001
Adjusted R Square	-0.052
Standard Error	256.990
Observations	21.000

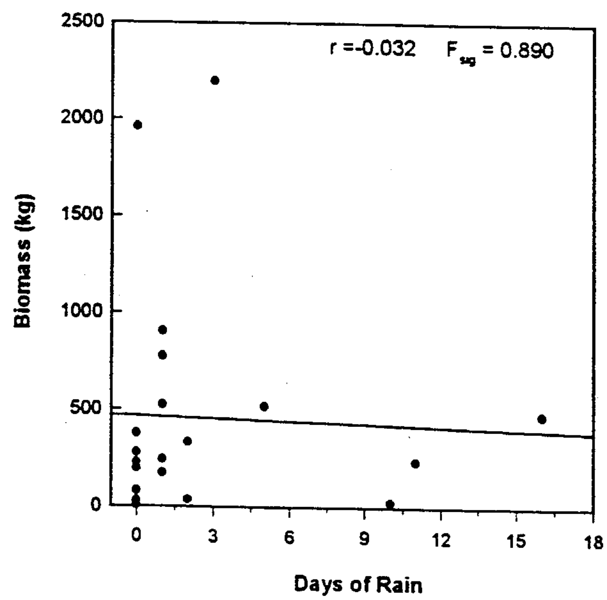
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1054.500	1054.500	0.016	0.901
Residual	19.000	1254834.738	66043.934		
Total	20.000	1255889.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	154.445	65.413	2.361	0.028	17.535	291.356
x1	-1.655	13.095	-0.126	0.901	-29.063	25.753

Appendix G-3. (continued)

Biomass vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.032
R Square	0.001
Adjusted R Square	-0.052
Standard Error	608.325
Observations	21.000

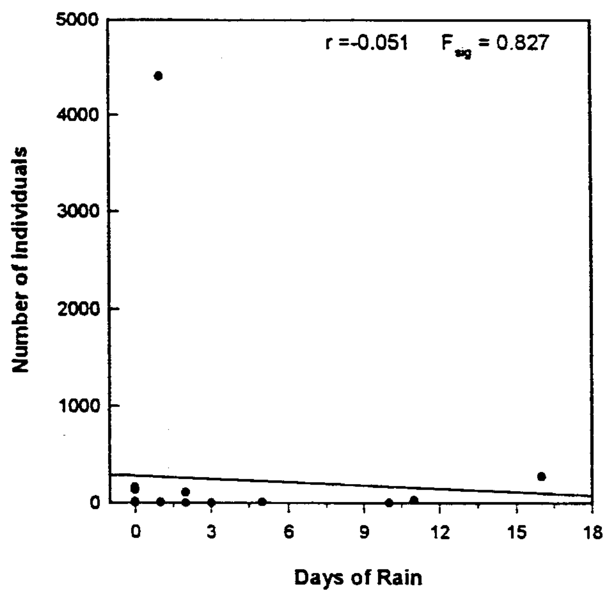
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	7273.260	7273.260	0.020	0.890
Residual	19.000	7031120.445	370058.971		
Total	20.000	7038393.705			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	469.831	154.839	3.034	0.007	145.749	793.913
x1	-4.346	30.997	-0.140	0.890	-69.224	60.533

Appendix G-3. (continued)

Umbrina roncador Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.051
R Square	0.003
Adjusted R Square	-0.050
Standard Error	977.810
Observations	21.000

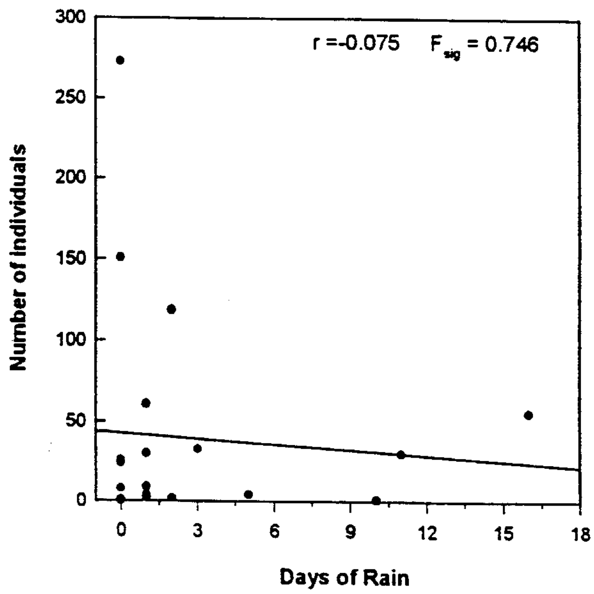
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	46995.971	46995.971	0.049	0.827
Residual	19.000	18166134.982	956112.367		
Total	20.000	18213130.952			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	282.024	248.885	1.133	0.271	-238.899	802.947
x1	-11.046	49.825	-0.222	0.827	-115.330	93.238

Appendix G-3. (continued)

Chromis punctipinnis Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.075
R Square	0.006
Adjusted R Square	-0.047
Standard Error	68.460
Observations	21.000

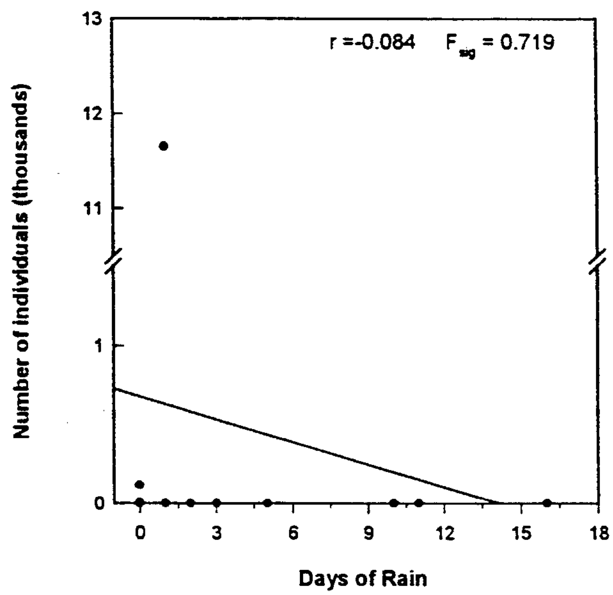
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	506.268	506.268	0.108	0.746
Residual	19.000	89048.018	4686.738		
Total	20.000	89554.286			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	42.662	17.425	2.448	0.024	6.191	79.134
x1	-1.147	3.488	-0.329	0.746	-8.448	6.155

Appendix G-3. (continued)

Engraulis mordax Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.084
R Square	0.007
Adjusted R Square	-0.045
Standard Error	2597.210
Observations	21.000

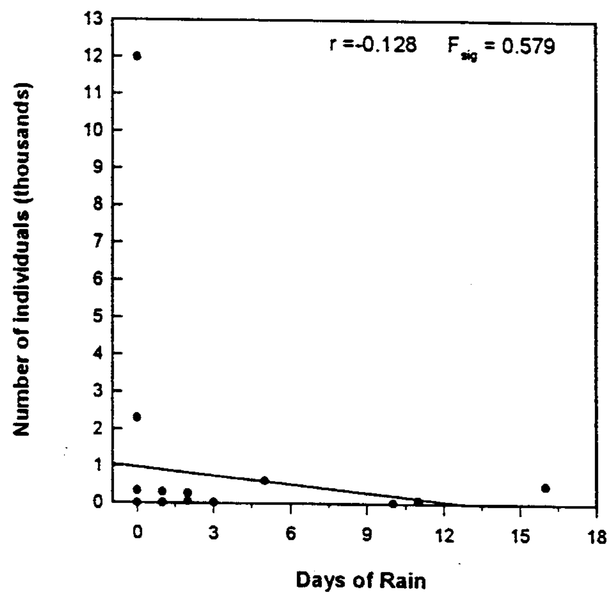
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	900777.126	900777.126	0.134	0.719
Residual	19.000	128164493.541	6745499.660		
Total	20.000	129065270.667			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	685.024	661.077	1.036	0.312	-698.627	2068.675
x1	-48.361	132.342	-0.365	0.719	-325.355	228.633

Appendix G-3. (continued)

Atherinopsis californiensis Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.128
R Square	0.017
Adjusted R Square	-0.035
Standard Error	2661.468
Observations	21.000

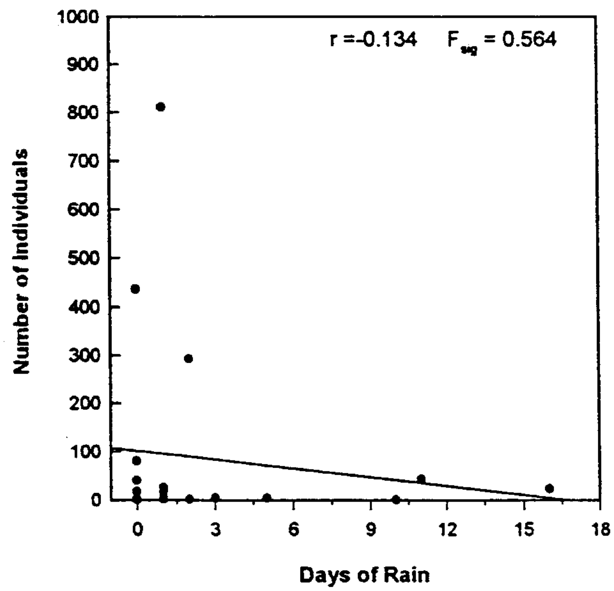
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	2258041.424	2258041.424	0.319	0.579
Residual	19.000	134584804.385	7083410.757		
Total	20.000	136842845.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	981.988	677.433	1.450	0.163	-435.896	2399.872
x1	-76.569	135.616	-0.565	0.579	-360.417	207.278

Appendix G-3. (continued)

Anisotremus davidsonii Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.134
R Square	0.018
Adjusted R Square	-0.034
Standard Error	201.991
Observations	21.000

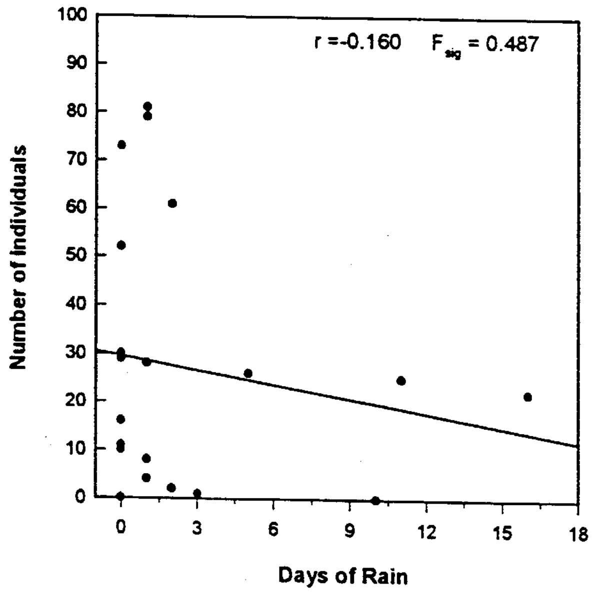
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	14085.440	14085.440	0.345	0.564
Residual	19.000	775204.370	40800.230		
Total	20.000	789289.810			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	101.646	51.413	1.977	0.062	-5.964	209.255
x1	-6.047	10.292	-0.588	0.563	-27.590	15.495

Appendix G-3. (continued)

Paralabrax clathratus Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.160
R Square	0.026
Adjusted R Square	-0.026
Standard Error	26.951
Observations	21.000

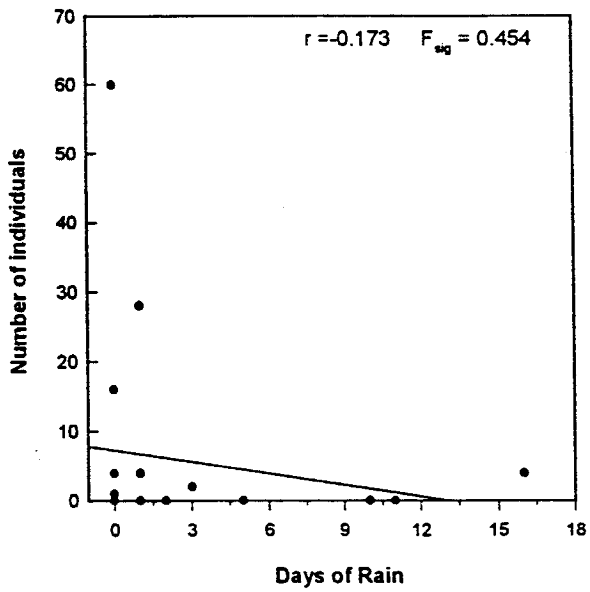
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	364.290	364.290	0.502	0.487
Residual	19.000	13800.662	726.351		
Total	20.000	14164.952			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	29.548	6.860	4.307	0.000	15.191	43.906
x1	-0.973	1.373	-0.708	0.487	-3.847	1.902

Appendix G-3. (continued)

Atractoscion nobilis Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.173
R Square	0.030
Adjusted R Square	-0.021
Standard Error	14.271
Observations	21.000

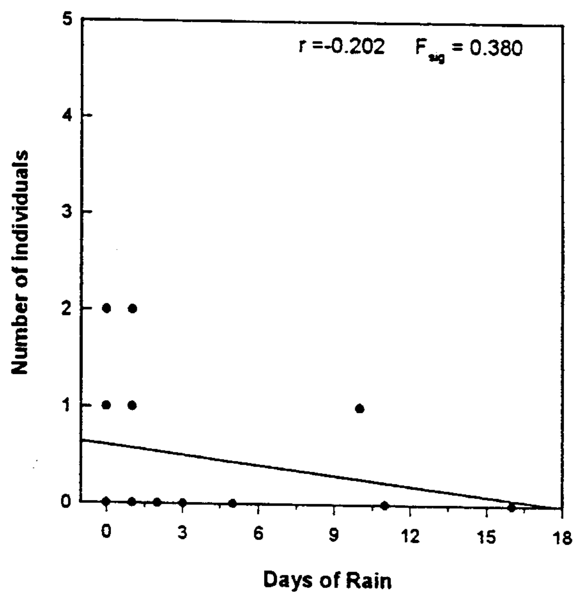
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	119.224	119.224	0.585	0.454
Residual	19.000	3869.347	203.650		
Total	20.000	3988.571			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	7.288	3.632	2.006	0.059	-0.315	14.890
x1	-0.556	0.727	-0.765	0.453	-2.078	0.966

Appendix G-3. (continued)

Paralichthys californicus Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

Multiple R	0.202
R Square	0.041
Adjusted R Square	-0.010
Standard Error	0.753
Observations	21.000

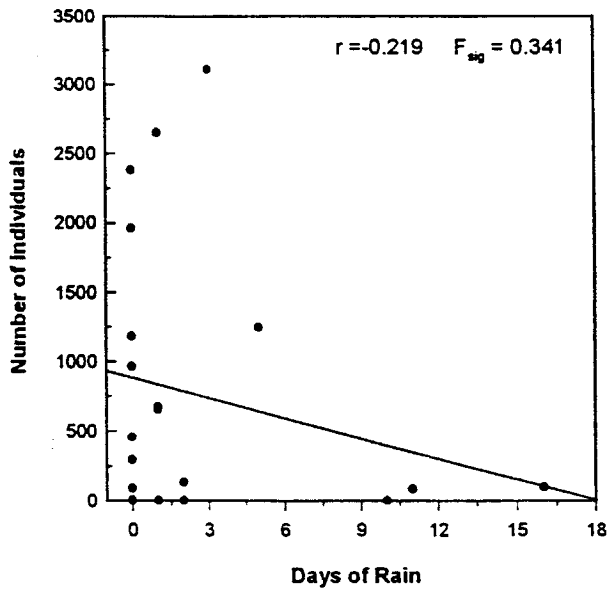
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	0.458	0.458	0.808	0.380
Residual	19.000	10.780	0.567		
Total	20.000	11.238			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.613	0.192	3.195	0.005	0.211	1.014
x1	-0.034	0.038	-0.899	0.379	-0.115	0.046

Appendix G-3. (continued)

Atherinops affinis Abundance vs. Days of Rain Reported Between Heat Treatments



Regression Statistics

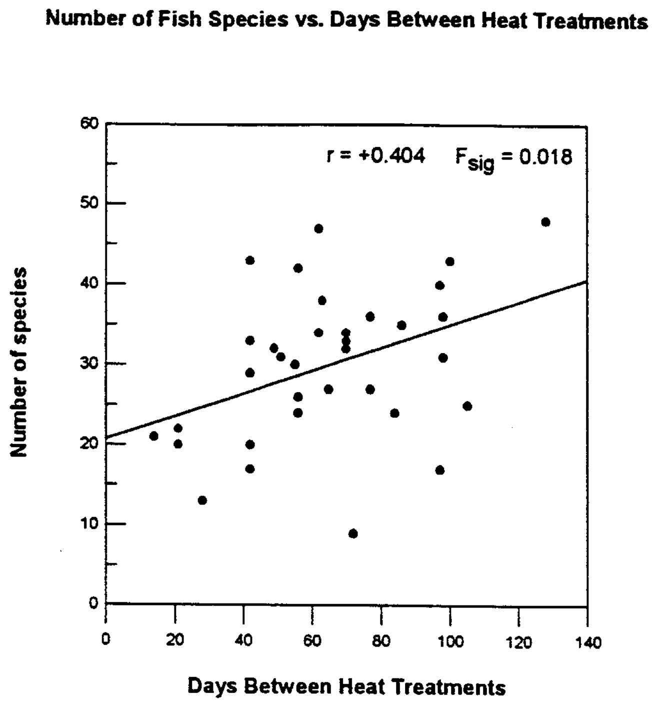
Multiple R	0.219
R Square	0.048
Adjusted R Square	-0.002
Standard Error	979.350
Observations	21.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	915441.433	915441.433	0.954	0.341
Residual	19.000	18223394.567	959126.030		
Total	20.000	19138836.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	887.366	249.277	3.560	0.002	365.622	1409.109
x1	-48.753	49.903	-0.977	0.340	-153.202	55.695

Appendix G-4. Correlations of number of days between heat treatments with 20 parameters.



Regression Statistics

Multiple R	0.404
R Square	0.163
Adjusted R Square	0.137
Standard Error	8.801
Observations	34.000

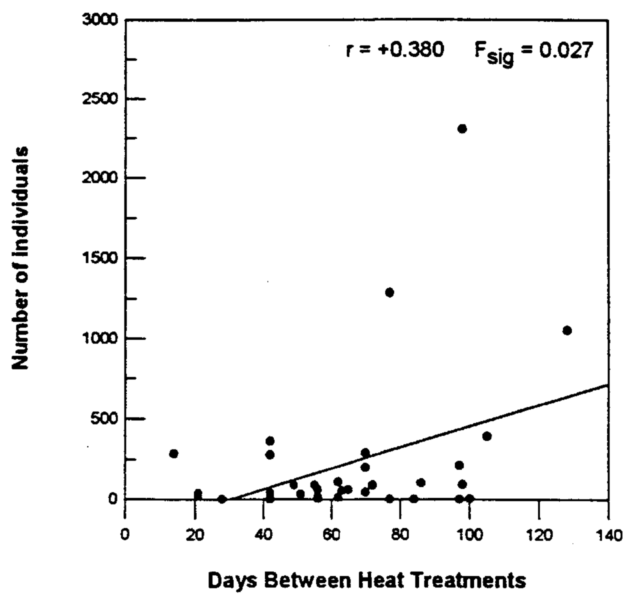
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	482.478	482.478	6.229	0.018
Residual	32.000	2478.493	77.453		
Total	33.000	2960.971			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	20.715	4.004	5.173	0.000	12.558	28.870
x1	0.143	0.057	2.496	0.018	0.026	0.260

Appendix G-4. (continued)

Xenistius californiensis Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.380
R Square	0.145
Adjusted R Square	0.118
Standard Error	434.285
Observations	34.000

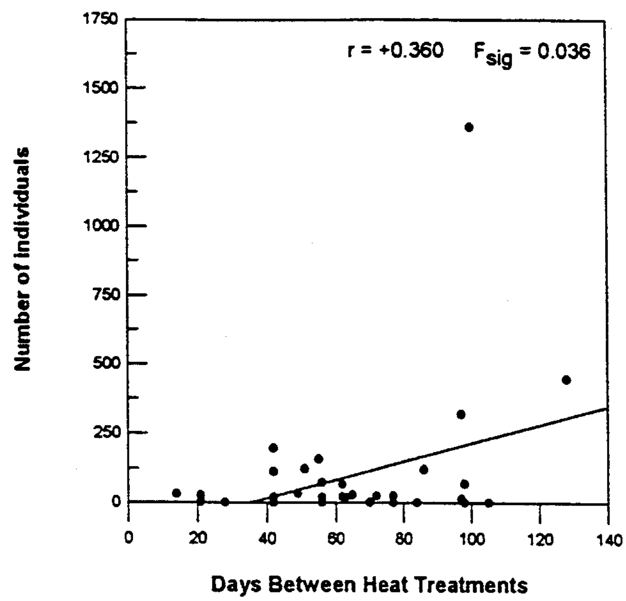
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1019904.520	1019904.520	5.408	0.027
Residual	32.000	6035305.510	188603.297		
Total	33.000	7055210.030			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-199.964	197.586	-1.012	0.319	-602.433	202.505
x1	6.583	2.831	2.325	0.026	0.817	12.350

Appendix G-4. (continued)

Hyperprosopon argenteum Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.360
R Square	0.130
Adjusted R Square	0.103
Standard Error	230.835
Observations	34.000

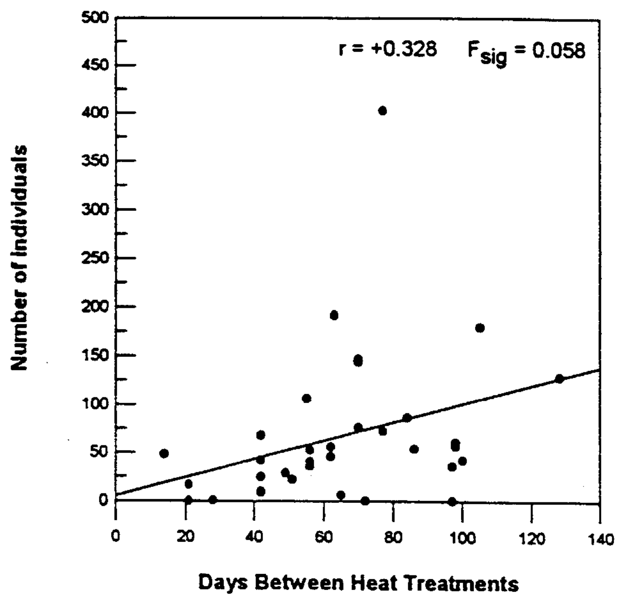
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	254670.106	254670.106	4.779	0.036
Residual	32.000	1705112.280	53284.759		
Total	33.000	1959782.380			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-115.104	105.023	-1.096	0.281	-329.028	98.820
x1	3.290	1.505	2.186	0.036	0.225	6.355

Appendix G-4. (continued)

Paralabrax nebulifer Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.328
R Square	0.107
Adjusted R Square	0.080
Standard Error	74.813
Observations	34.000

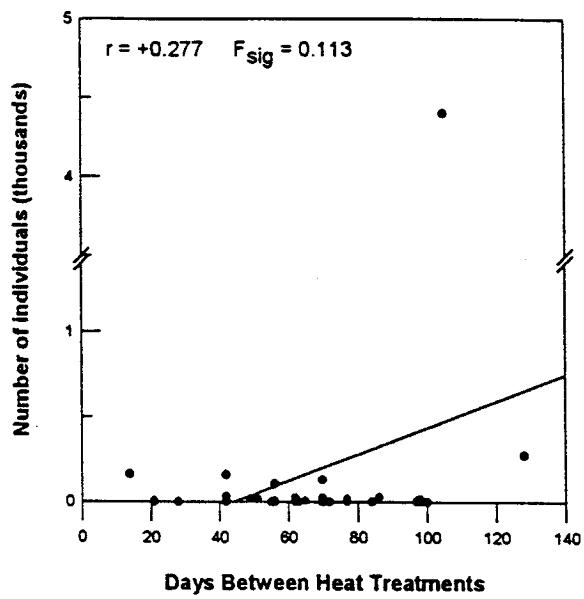
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	32.000	21550.581	21550.581	3.850	0.058
Residual	32.000	179103.890	5596.997		
Total	33.000	200654.471			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	5.666	34.038	0.166	0.869	-63.666	74.999
x1	0.957	0.488	1.962	0.058	-0.036	1.950

Appendix G-4. (continued)

Umbrina roncador Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.277
R Square	0.077
Adjusted R Square	0.048
Standard Error	734.284
Observations	34.000

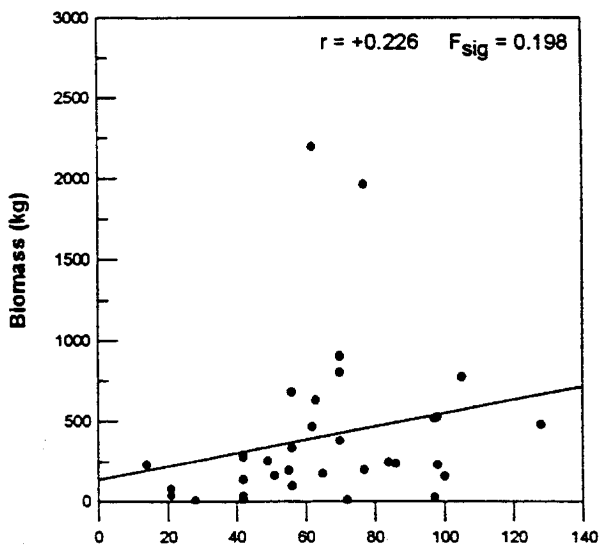
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1433410.490	1433410.490	2.659	0.113
Residual	32.000	17253514.200	539172.320		
Total	33.000	18686924.700			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-343.620	334.076	-1.029	0.311	-1024.110	336.871
x1	7.804	4.787	1.631	0.113	-1.945	17.554

Appendix G-4. (continued)

Total Fish Biomass vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.226
R Square	0.051
Adjusted R Square	0.022
Standard Error	485.272
Observations	34.000

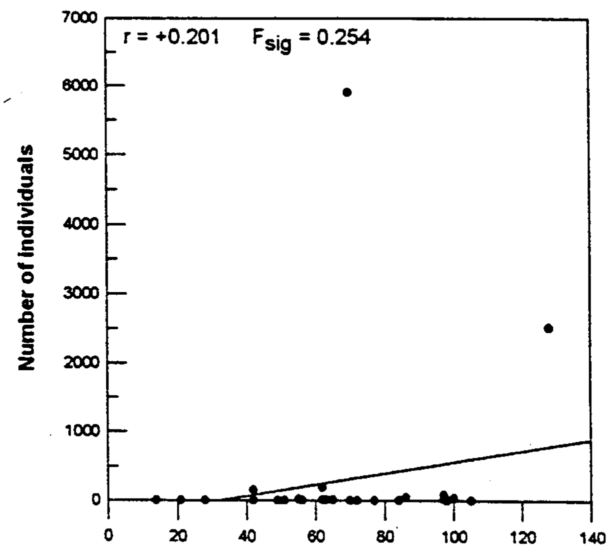
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	407013.326	407013.326	1.728	0.198
Residual	32.000	7535639.110	235488.722		
Total	33.000	7942652.430			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	135.221	220.784	0.612	0.544	-314.500	584.942
x1	4.159	3.163	1.315	0.198	-2.285	10.602

Appendix G-4. (continued)

Genyonemus lineatus Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.201
R Square	0.041
Adjusted R Square	0.011
Standard Error	1079.524
Observations	34.000

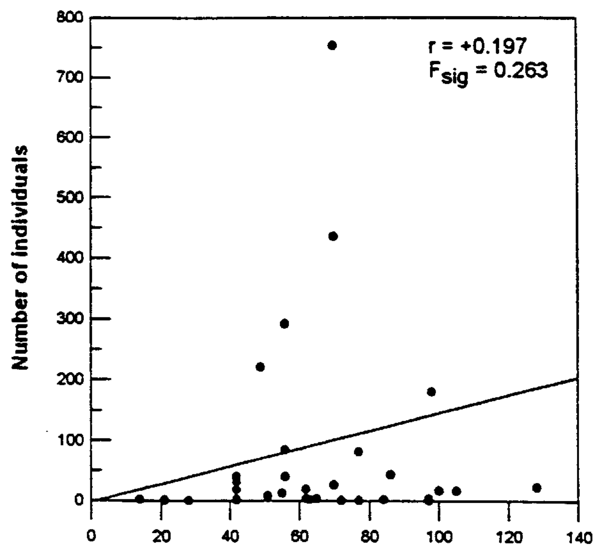
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1575608.960	1575608.960	1.352	0.254
Residual	32.000	37291883.400	1165371.360		
Total	33.000	38867492.400			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-262.407	491.150	-0.534	0.597	-1262.845	738.032
x1	8.182	7.037	1.163	0.253	-6.151	22.516

Appendix G-4. (continued)

Anisotremus davidsonii Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.197
R Square	0.039
Adjusted R Square	0.009
Standard Error	198.110
Observations	34.000

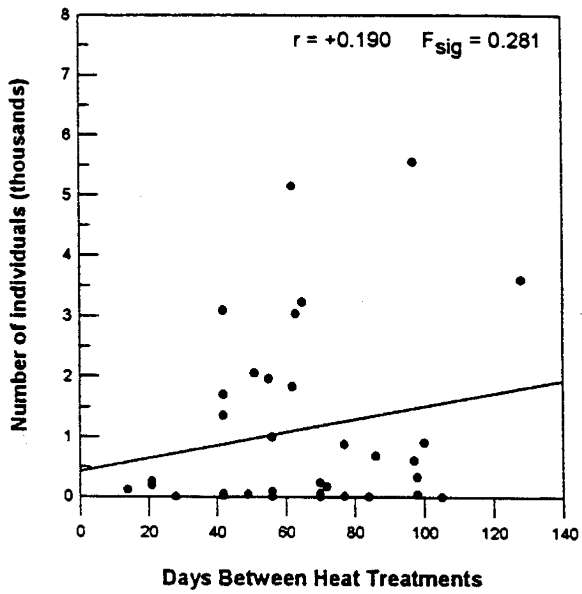
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	50959.872	50959.872	1.298	0.263
Residual	32.000	1255926.160	39247.692		
Total	33.000	1306886.030			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1.748	90.134	-0.019	0.985	-185.344	181.849
x1	1.472	1.291	1.139	0.263	-1.159	4.102

Appendix G-4. (continued)

Seriphus politus vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.190
R Square	0.036
Adjusted R Square	0.006
Standard Error	1514.333
Observations	34.000

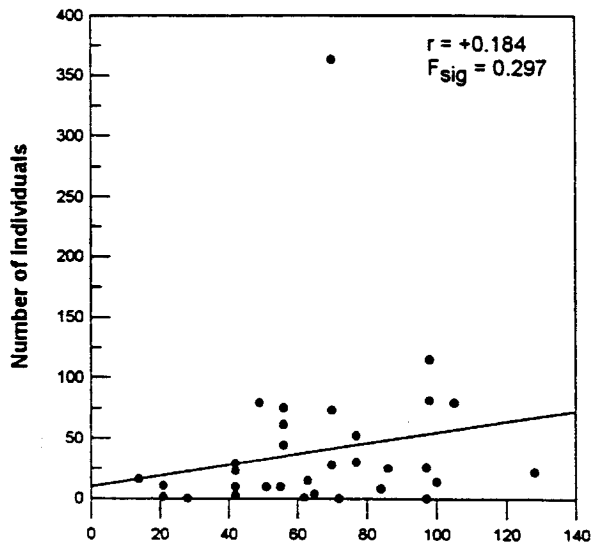
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	2756746.130	2756746.130	1.202	0.281
Residual	32.000	73382589.300	2293205.920		
Total	33.000	76139335.400			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	426.640	688.975	0.619	0.540	-976.754	1830.035
x1	10.823	9.871	1.096	0.281	-9.284	30.930

Appendix G-4. (continued)

Paralabrax clathratus Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.184
R Square	0.034
Adjusted R Square	0.004
Standard Error	64.601
Observations	34.000

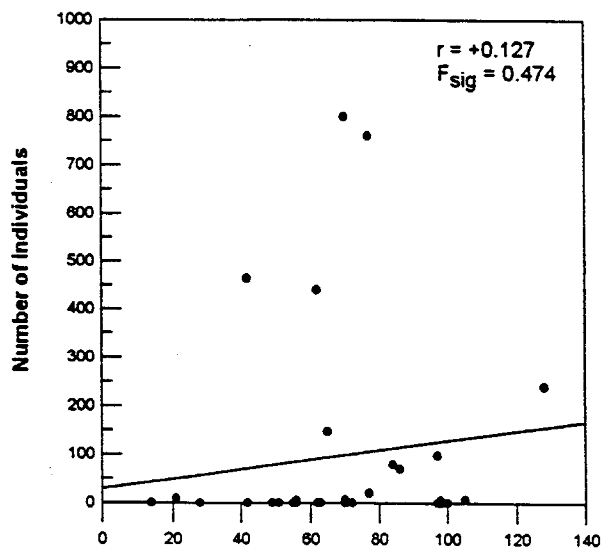
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	4693.581	4693.581	1.125	0.297
Residual	32.000	133543.360	4173.230		
Total	33.000	138236.941			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	9.953	29.391	0.339	0.737	-49.915	69.821
x1	0.447	0.421	1.061	0.297	-0.411	1.304

Appendix G-4. (continued)

Scomber japonicus Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.127
R Square	0.016
Adjusted R Square	-0.015
Standard Error	210.009
Observations	34.000

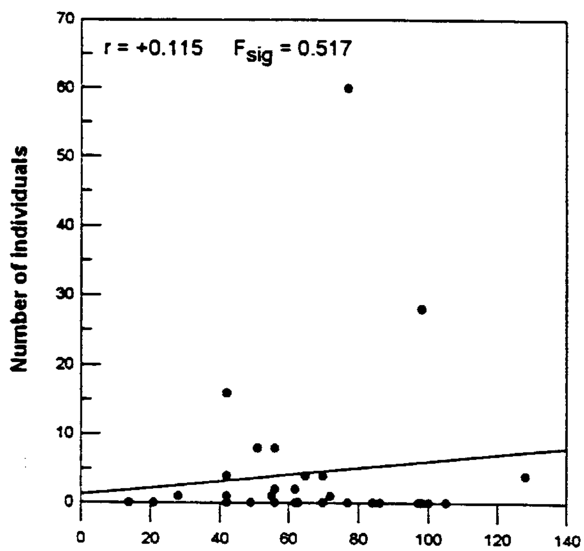
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	23161.951	23161.951	0.525	0.474
Residual	32.000	1411320.990	44103.781		
Total	33.000	1434482.940			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	29.042	95.548	0.304	0.763	-165.582	223.666
x1	0.992	1.369	0.725	0.474	-1.796	3.781

Appendix G-4. (continued)

Atractoscion nobilis Abundance vs. Days Between Heat Treatments



Regression Statistics

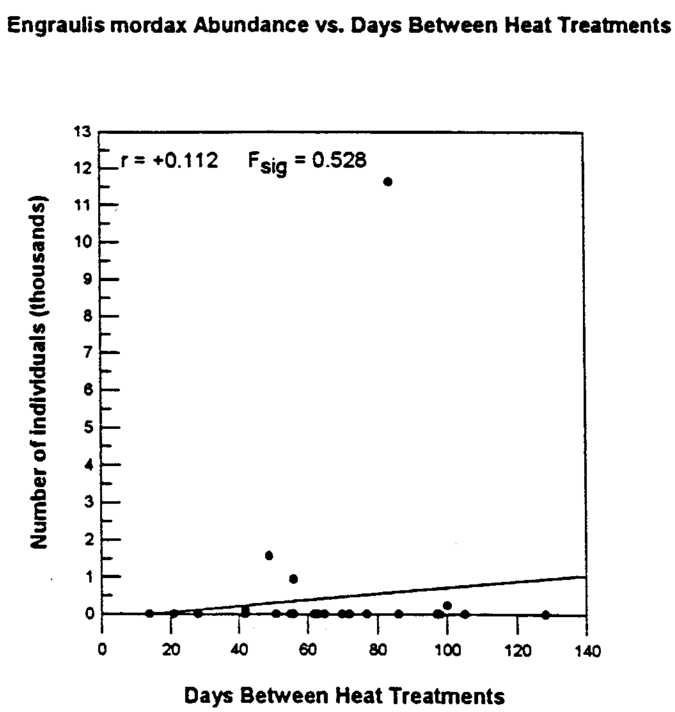
Multiple R	0.115
R Square	0.013
Adjusted R Square	-0.018
Standard Error	11.402
Observations	34.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	55.731	55.731	0.429	0.517
Residual	32.000	4160.034	130.001		
Total	33.000	4215.765			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.207	5.187	0.233	0.817	-9.360	11.774
x1	0.049	0.074	0.655	0.517	-0.103	0.200

Appendix G-4. (continued)



Regression Statistics

Multiple R	0.112
R Square	0.013
Adjusted R Square	-0.018
Standard Error	2024.766
Observations	34.000

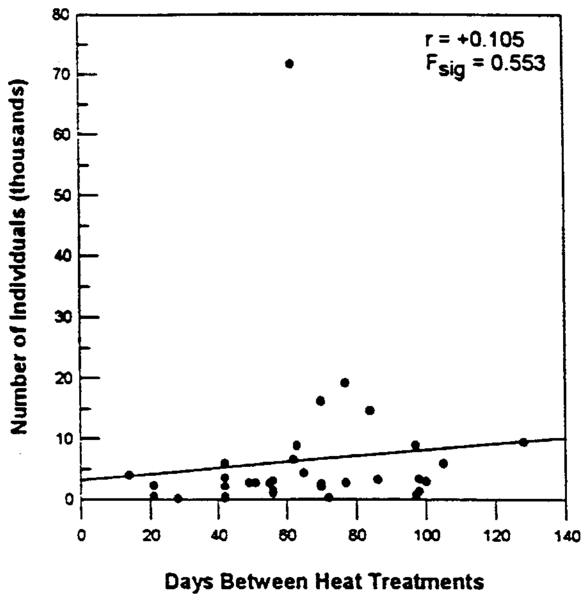
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1669144.670	1669144.670	0.407	0.528
Residual	32.000	131189692.000	4099677.870		
Total	33.000	132858837.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-116.940	921.206	-0.127	0.900	-1993.373	1759.493
x1	8.422	13.199	0.638	0.528	-18.463	35.306

Appendix G-4. (continued)

Total Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.105
R Square	0.011
Adjusted R Square	-0.020
Standard Error	12522.590
Observations	34.000

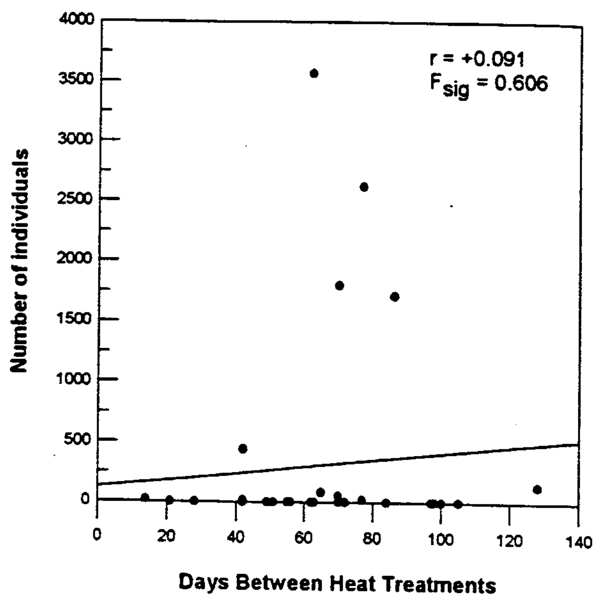
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	56398974.400	56398974.400	0.360	0.553
Residual	32.000	5018087299.000	156815228.000		
Total	33.000	5074486274.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3226.461	5697.388	0.566	0.575	-8378.730	14831.650
x1	48.954	81.630	0.600	0.553	-117.320	215.228

Appendix G-4. (continued)

Sardinops sagax Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.092
R Square	0.008
Adjusted R Square	-0.023
Standard Error	840.882
Observations	34.000

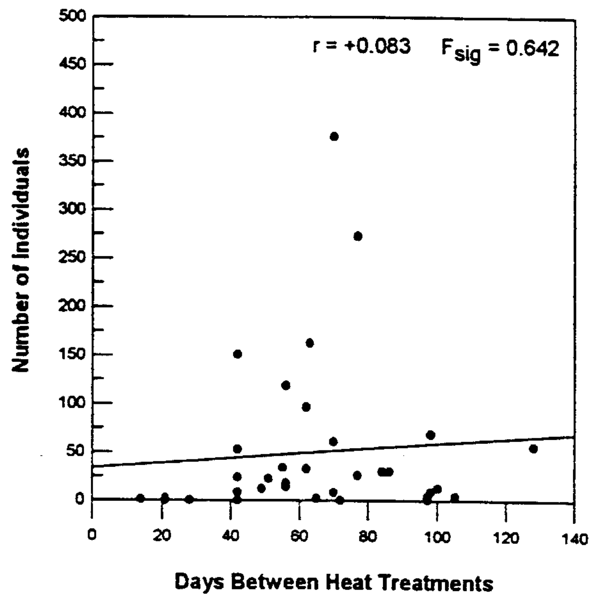
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	191847.054	191847.054	0.271	0.606
Residual	32.000	22626663.900	707083.246		
Total	33.000	22818510.900			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	124.245	382.575	0.325	0.747	-655.035	903.525
x1	2.855	5.481	0.521	0.606	-8.310	14.020

Appendix G-4. (continued)

Chromis punctipinnis Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.083
R Square	0.007
Adjusted R Square	-0.024
Standard Error	83.338
Observations	34.000

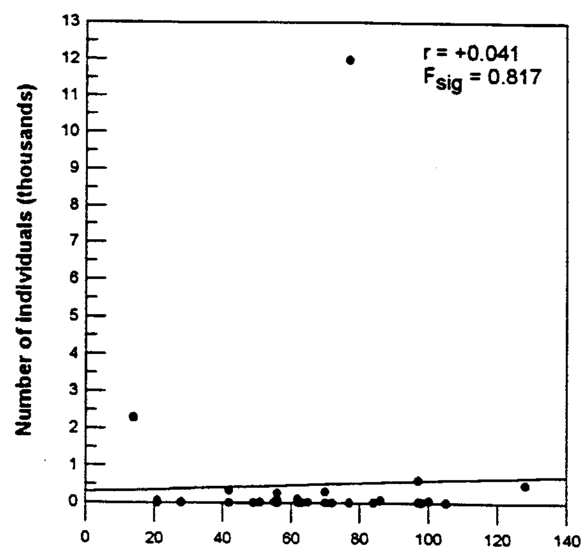
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1529.177	1529.177	0.220	0.642
Residual	32.000	222247.058	6945.221		
Total	33.000	223776.235			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	33.933	37.916	0.895	0.377	-43.300	111.165
x1	0.255	0.543	0.469	0.642	-0.852	1.361

Appendix G-4. (continued)

Atherinopsis californiensis Abundance vs. Days Between Heat Treatments



Regression Statistics

Multiple R	0.041
R Square	0.002
Adjusted R Square	-0.030
Standard Error	2100.994
Observations	34.000

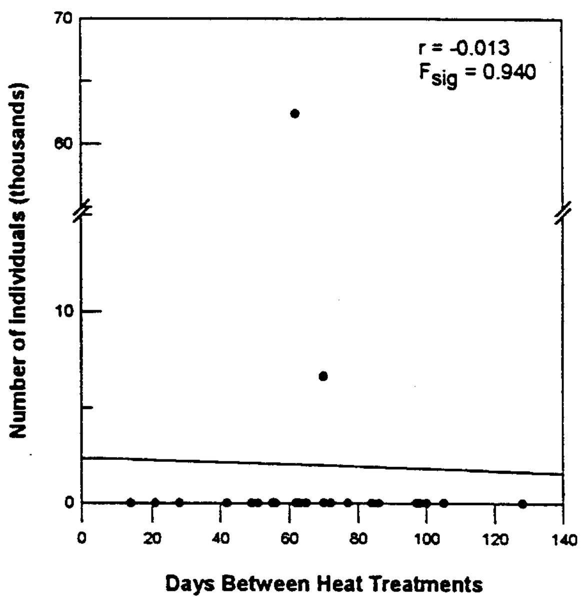
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	239480.419	239480.419	0.054	0.817
Residual	32.000	141253643.000	4414176.330		
Total	33.000	141493123.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	288.482	955.887	0.302	0.765	-1658.594	2235.559
x1	3.190	13.696	0.233	0.817	-24.707	31.087

Appendix G-4. (continued)

Trachurus symmetricus Abundance vs. Days Between Heat Treatments



Regression Statistics

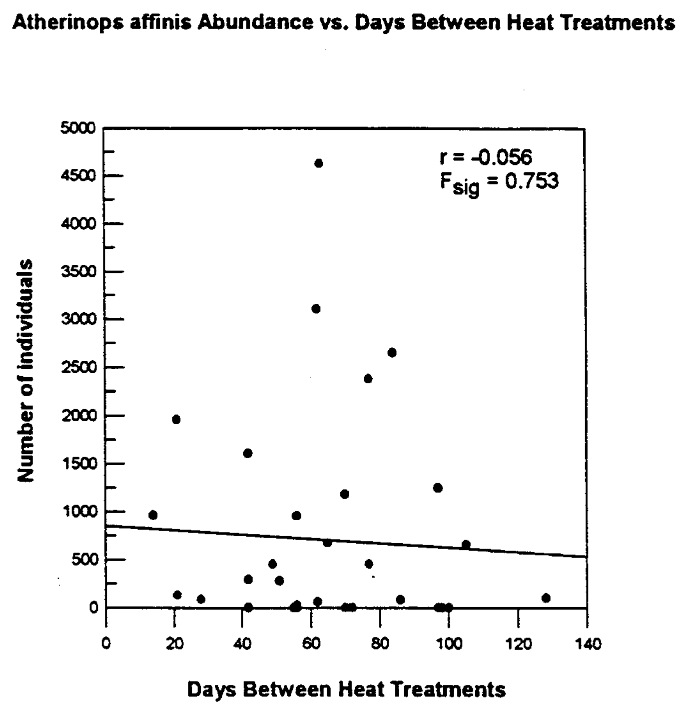
Multiple R	0.013
R Square	0.000
Adjusted R Square	-0.031
Standard Error	10895.790
Observations	34.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	690985.936	690985.936	0.006	0.940
Residual	32.000	3798983148.000	118718223.000		
Total	33.000	3799674134.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2385.416	4957.245	0.481	0.634	-7712.154	12482.990
x1	-5.419	71.025	-0.076	0.940	-150.092	139.255

Appendix G-4. (continued)



Regression Statistics

Multiple R	0.056
R Square	0.003
Adjusted R Square	-0.028
Standard Error	1109.928
Observations	34.000

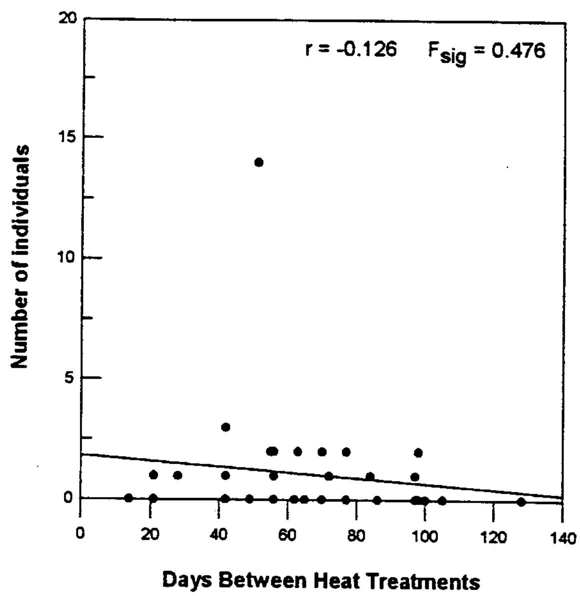
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	124224.742	124224.742	0.101	0.753
Residual	32.000	39422075.900	1231939.870		
Total	33.000	39546300.600			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	855.263	504.983	1.694	0.100	-173.352	1883.878
x1	-2.298	7.235	-0.318	0.753	-17.035	12.440

Appendix G-4. (continued)

Paralichthys californicus Abundance vs. Days Between Heat Treatments



Regression Statistics

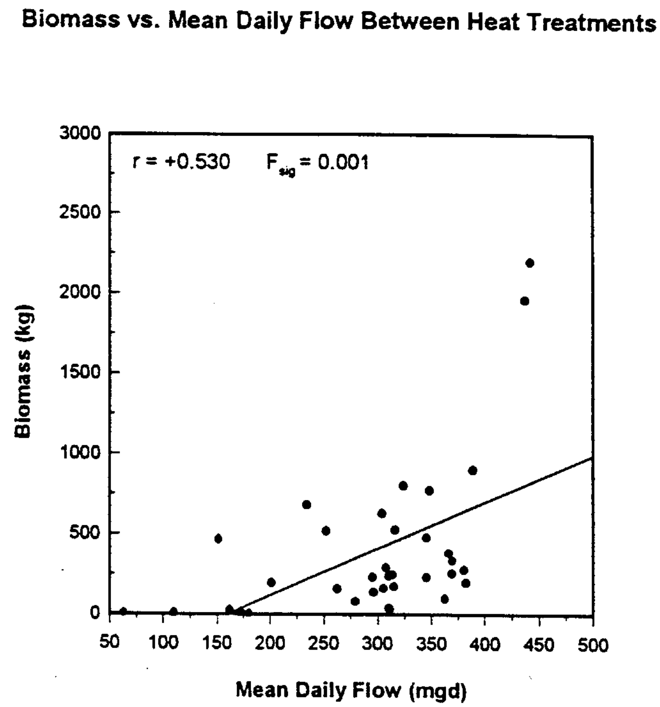
Multiple R	0.126
R Square	0.016
Adjusted R Square	-0.015
Standard Error	2.460
Observations	34.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	3.142	3.142	0.519	0.476
Residual	32.000	193.593	6.050		
Total	33.000	196.735			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.835	1.119	1.640	0.111	-0.444	4.115
x1	-0.012	0.016	-0.721	0.476	-0.044	0.021

Appendix G-5. Correlations of mean daily circulating water flow between heat treatments with 20 parameters.



Regression Statistics

Multiple R	0.52985149
R Square	0.2807426
Adjusted R Square	0.25894692
Standard Error	420.07606
Observations	35

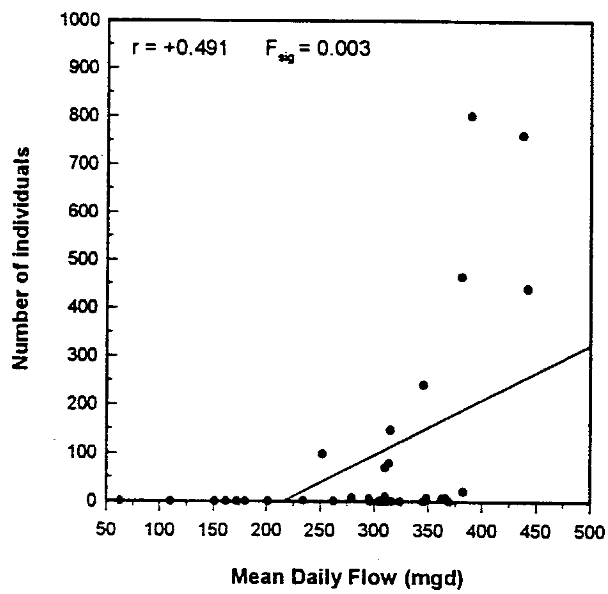
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	2272970.377	2272970.377	12.8806539	0.001062301
Residual	33	5823308.563	176463.8958		
Total	34	8096278.939			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-465.32096	249.3957539	-1.865793445	0.07071734	-972.7208417	42.0789158
x1	2.91112387	0.811132362	3.588962796	0.00103316	1.260861363	4.56138638

Appendix G-5. (continued)

Scomber japonicus Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.49090345
R Square	0.2409862
Adjusted R Square	0.21798578
Standard Error	182.174885
Observations	35

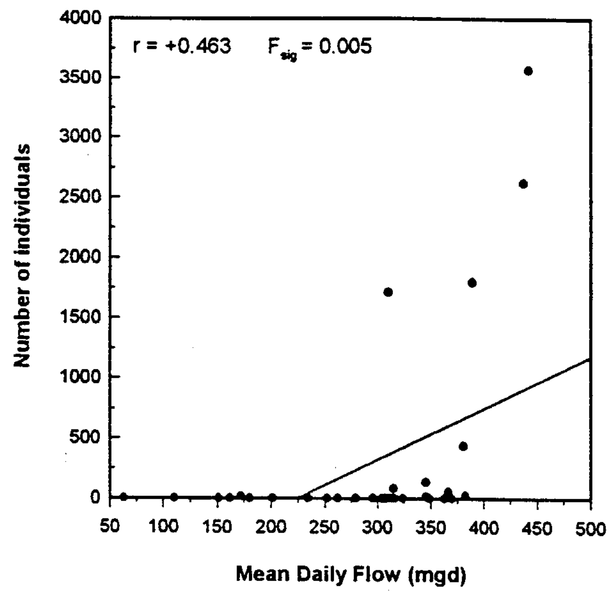
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	347723.0185	347723.0185	10.4774702	0.002751072
Residual	33	1095193.724	33187.68862		
Total	34	1442916.743			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-245.0852	108.1557534	-2.266039402	0.0299303	-465.1299081	-25.040489
x1	1.13862448	0.351764737	3.236892059	0.00269559	0.422953178	1.85429579

Appendix G-5. (continued)

Sardinops sagax Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.46299889
R Square	0.21436797
Adjusted R Square	0.19056094
Standard Error	738.543602
Observations	35

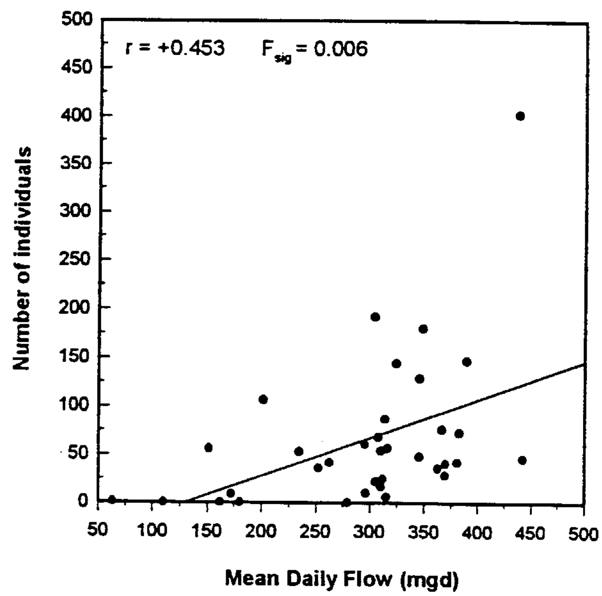
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	4911418.49	4911418.49	9.00439754	0.005097501
Residual	33	17999739.51	545446.6518		
Total	34	22911158			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-961.26991	438.4673541	-2.192340892	0.03529779	-1853.339157	-69.200664
x1	4.27924614	1.426067024	3.000732834	0.00501582	1.377888667	7.18060362

Appendix G-5. (continued)

Paralabrax nebulifer Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.45295933
R Square	0.20517216
Adjusted R Square	0.18108646
Standard Error	70.2822862
Observations	35

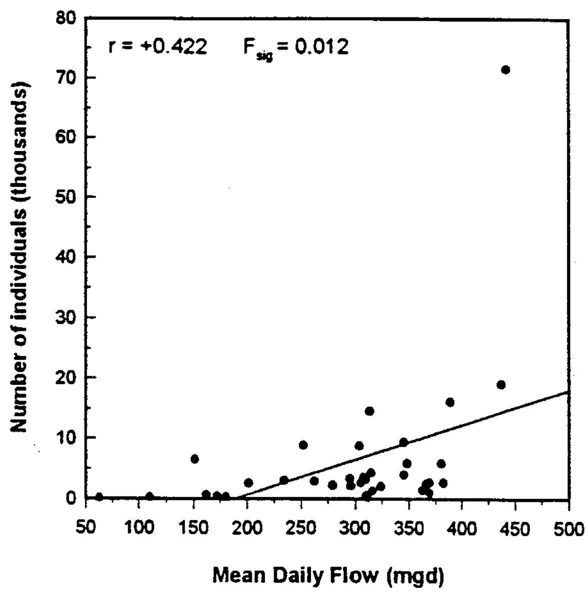
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	42077.60831	42077.60831	8.51842466	0.006287358
Residual	33	163006.7917	4939.599748		
Total	34	205084.4			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-51.142795	41.726024	-1.225681011	0.22874124	-136.0350967	33.7495061
x1	0.39608584	0.135709321	2.91863404	0.00619481	0.119982935	0.67218875

Appendix G-5. (continued)

Total Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.42157165
R Square	0.17772266
Adjusted R Square	0.15280516
Standard Error	11284.1038
Observations	35

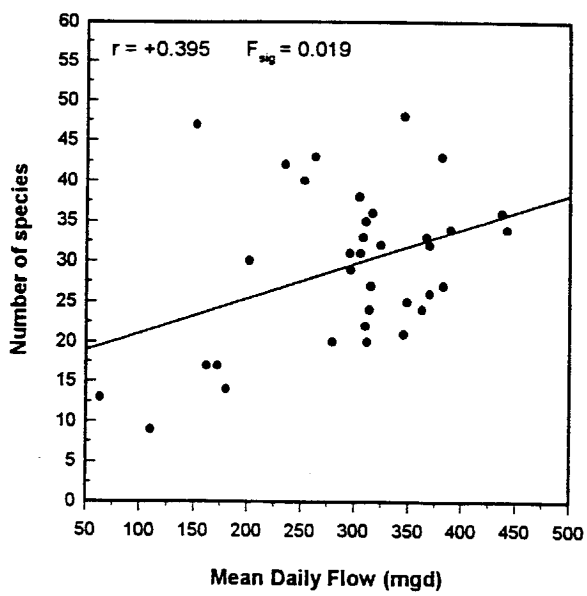
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	908181288.8	908181288.8	7.13244463	0.011659886
Residual	33	4201922917	127330997.5		
Total	34	5110104206			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-10932.855	6699.280995	-1.631944533	0.1119204	-24562.65547	2696.94548
x1	58.1902298	21.78867737	2.670663705	0.01152933	13.86079727	102.519662

Appendix G-5. (continued)

Number of Fish Species vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

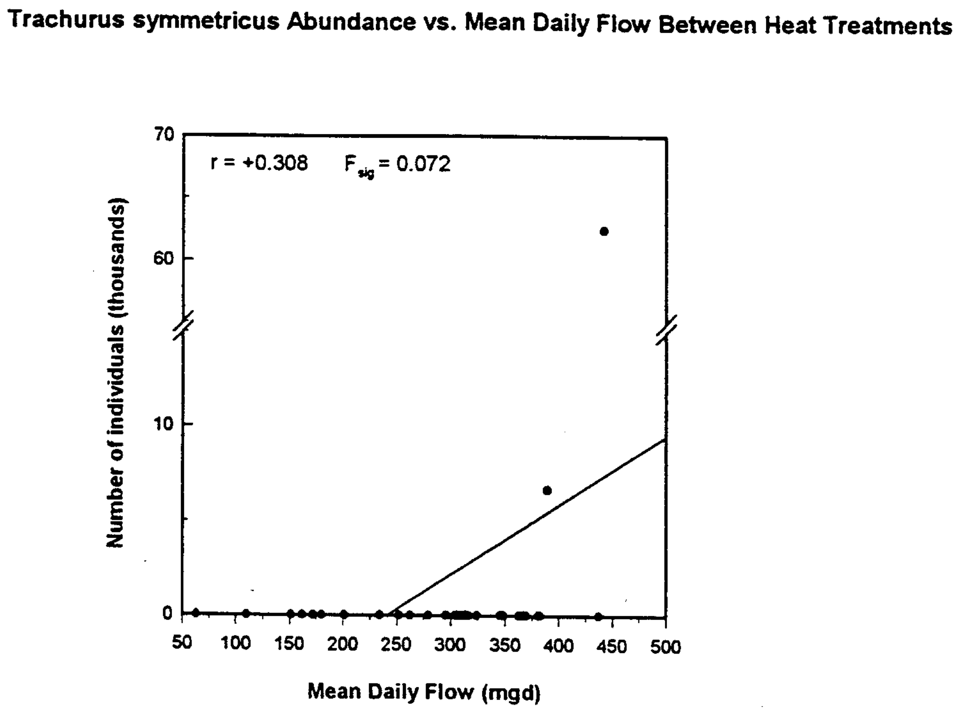
Multiple R	0.39458906
R Square	0.15570053
Adjusted R Square	0.1301157
Standard Error	9.06063731
Observations	35

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	499.602956	499.602956	6.0856575	0.018990352
Residual	33	2709.139901	82.09514852		
Total	34	3208.742857			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	16.7934084	5.379226981	3.121899942	0.00365624	5.849280139	27.7375367
x1	0.04315949	0.017495346	2.466912543	0.01882404	0.007564911	0.07875407

Appendix G-5. (continued)



Regression Statistics

Multiple R	0.30762006
R Square	0.0946301
Adjusted R Square	0.06719465
Standard Error	10215.4809
Observations	35

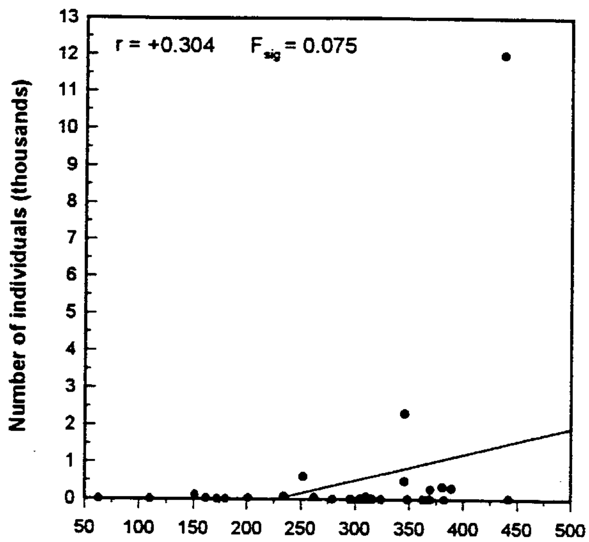
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	359943900	359943900	3.44919054	0.072226837
Residual	33	3443749650	104356050		
Total	34	3803693550			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-8820.4692	6064.848263	-1.454359418	0.1550168	-21159.50554	3518.56716
x1	36.6337356	19.72525442	1.857199649	0.07196281	-3.497628101	76.7650993

Appendix G-5. (continued)

Atherinopsis californiensis Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.30438983
R Square	0.09265317
Adjusted R Square	0.06515781
Standard Error	1974.0671
Observations	35

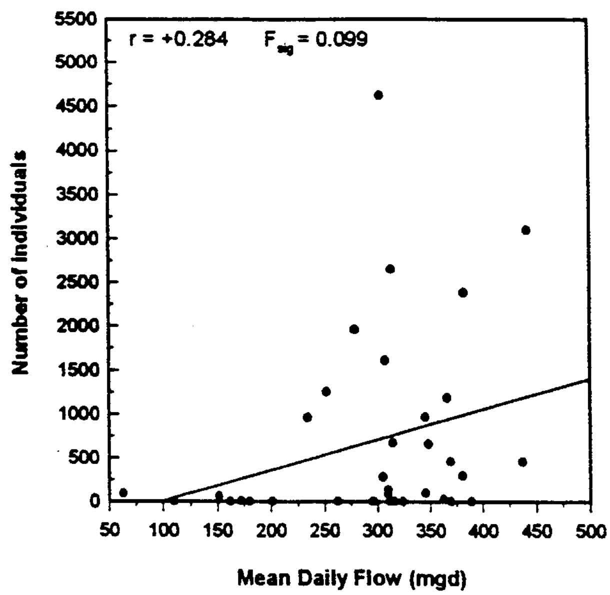
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	13131814.01	13131814.01	3.36977497	0.075428105
Residual	33	128599050.6	3896940.926		
Total	34	141730864.6			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1581.8002	1171.987649	-1.349673099	0.1860393	-3966.228892	802.628488
x1	6.99723015	3.811761408	1.835694684	0.07516192	-0.757862889	14.7523232

Appendix G-5. (continued)

Atherinops affinis Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.28364857
R Square	0.08045651
Adjusted R Square	0.05259156
Standard Error	1056.16099
Observations	35

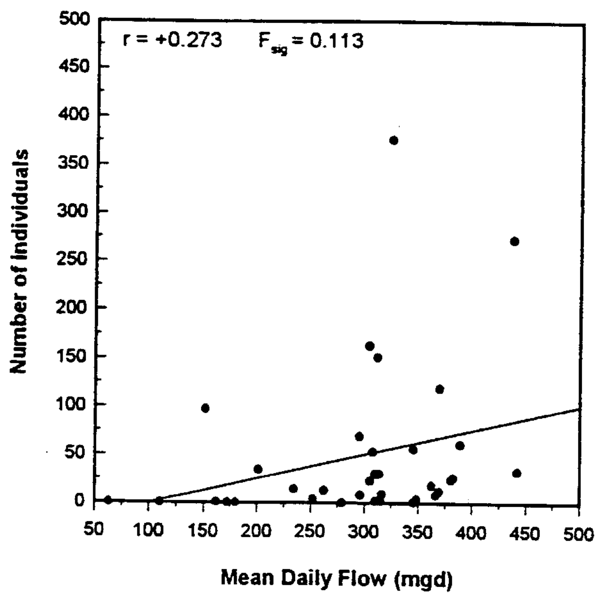
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	3220795.189	3220795.189	2.8873728	0.098686176
Residual	33	36810709.5	1115476.045		
Total	34	40031504.69			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-334.83425	627.0342272	-0.533996765	0.59681821	-1610.545987	940.87749
x1	3.46533601	2.039360117	1.699227117	0.09840997	-0.683776631	7.61444866

Appendix G-5. (continued)

Chromis punctipinnis Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.27304494
R Square	0.07455354
Adjusted R Square	0.0465097
Standard Error	79.6541023
Observations	35

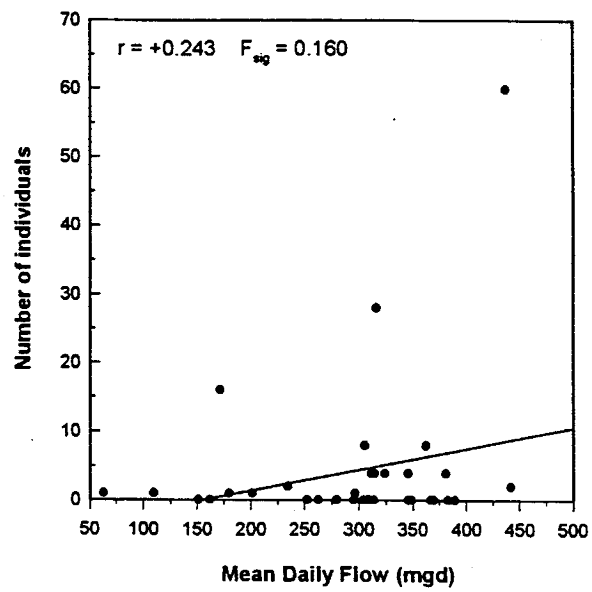
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	16867.36276	16867.36276	2.65846465	0.112509352
Residual	33	209377.6087	6344.77602		
Total	34	226244.9714			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-24.942818	47.28999536	-0.527443877	0.60131059	-121.1551137	71.2694768
x1	0.25077682	0.153805528	1.630479884	0.11223073	-0.062143128	0.56369677

Appendix G-5. (continued)

Atractoscion nobilis Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.24271729
R Square	0.05891168
Adjusted R Square	0.03039386
Standard Error	10.9788841
Observations	35

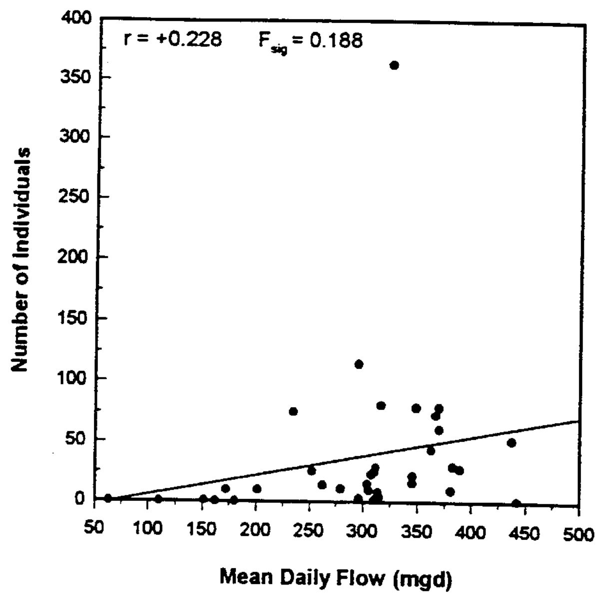
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	249.0011752	249.0011752	2.06578443	0.160052352
Residual	33	3977.684539	120.5358951		
Total	34	4226.685714			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-4.7234553	6.518074534	-0.724670338	0.47361213	-17.98458814	8.53767759
x1	0.03046944	0.021199323	1.437283698	0.15977736	-0.01266094	0.07359982

Appendix G-5. (continued)

Paralabrax clathratus Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.22804757
R Square	0.05200569
Adjusted R Square	0.02327859
Standard Error	63.3498913
Observations	35

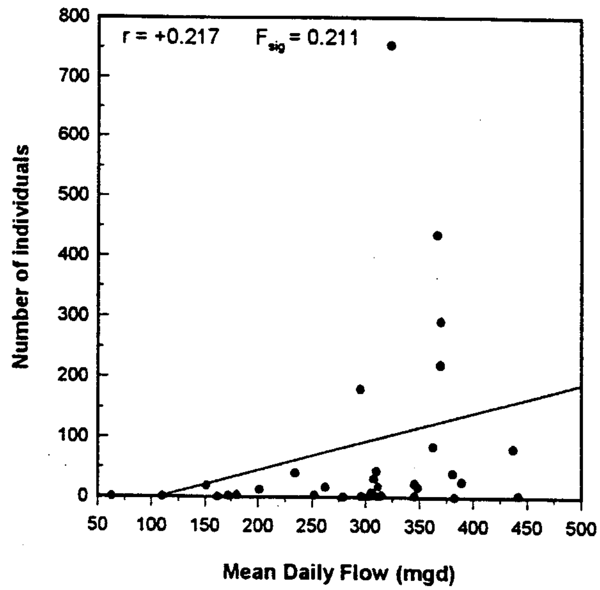
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	7265.254682	7265.254682	1.81033561	0.187640798
Residual	33	132435.8882	4013.208733		
Total	34	139701.1429			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-10.79557	37.61031735	-0.28703747	0.77582574	-87.31439701	65.7232563
x1	0.16458461	0.122323436	1.345487128	0.18737308	-0.084284491	0.41345371

Appendix G-5. (continued)

Anisotremus davidsonii Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.21695655
R Square	0.04707015
Adjusted R Square	0.01819348
Standard Error	194.839977
Observations	35

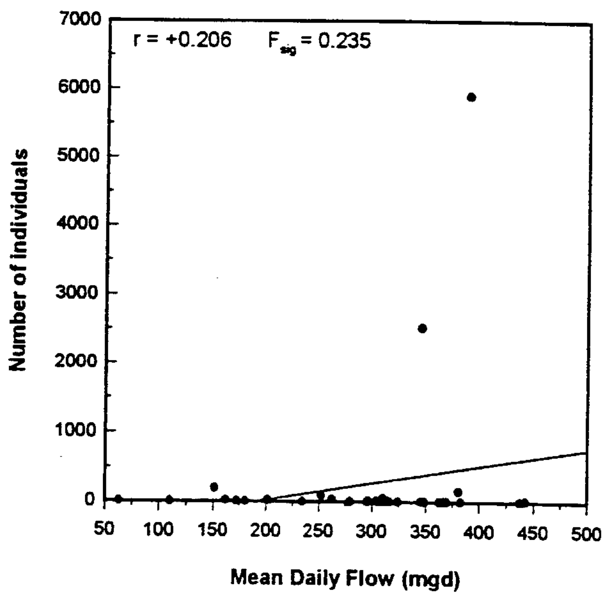
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	61880.62568	61880.62568	1.63004111	0.210608776
Residual	33	1252766.346	37962.61654		
Total	34	1314646.971			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-50.74491	115.674916	-0.438685516	0.6636645	-286.0874829	184.597662
x1	0.48033159	0.376219989	1.276730634	0.21034876	-0.285094345	1.24575752

Appendix G-5. (continued)

Genyonemus lineatus Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.20623434
R Square	0.0425326
Adjusted R Square	0.01351844
Standard Error	1062.87837
Observations	35

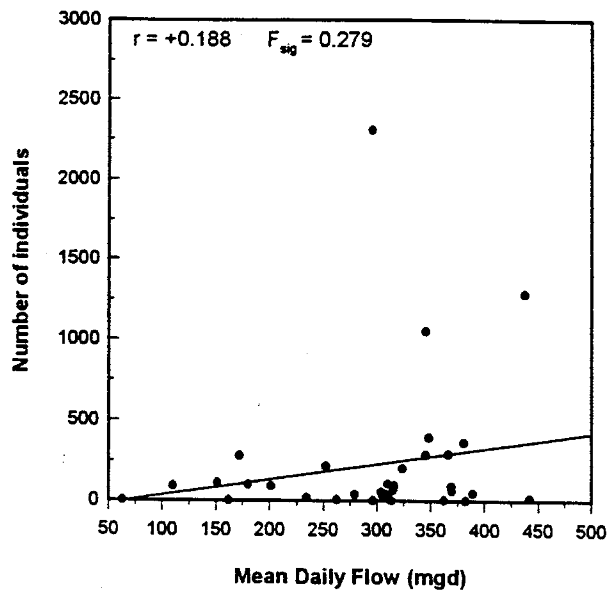
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	1656071.415	1656071.415	1.46592557	0.234589969
Residual	33	37280444.47	1129710.439		
Total	34	38936515.89			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-473.44999	631.0222814	-0.75029045	0.45824084	-1757.275494	810.375511
x1	2.48486803	2.052330826	1.210754131	0.23433905	-1.690633745	6.6603698

Appendix G-5. (continued)

Xenistius californiensis Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.18811124
R Square	0.03538584
Adjusted R Square	0.00615511
Standard Error	454.625333
Observations	35

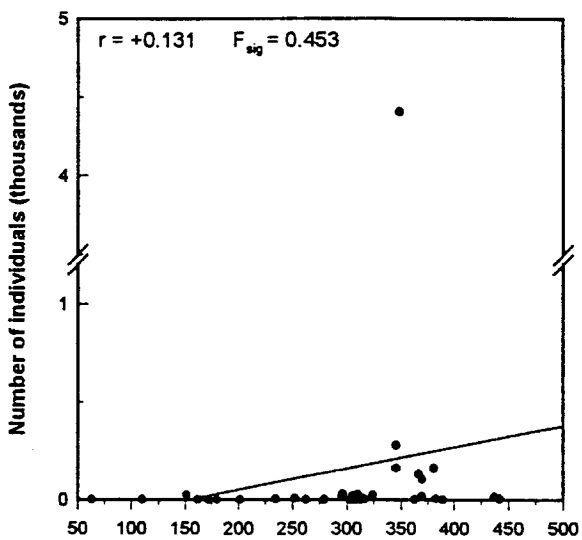
Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regression	1	250205.6183	250205.6183	1.21056968	0.279180884
Residual	33	6820578.382	206684.1934		
Total	34	7070784			

	Coefficients	Standard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	-62.677467	269.9073777	-0.232218429	0.81776049	-611.8085914	486.453657
x1	0.96585588	0.877844171	1.100258916	0.27894856	-0.820132935	2.75184469

Appendix G-5. (continued)

Umbrina roncador Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.13086635
R Square	0.017126
Adjusted R Square	-0.0126581
Standard Error	746.539785
Observations	35

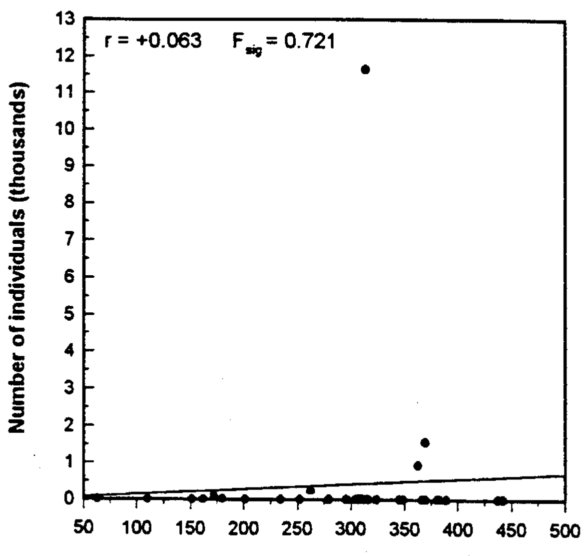
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	320463.067	320463.067	0.57500559	0.453658459
Residual	33	18391614.48	557321.6508		
Total	34	18712077.54			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-165.86199	443.2146234	-0.374224995	0.71056075	-1067.589636	735.865656
x1	1.09308212	1.441506998	0.758291233	0.45350114	-1.839688244	4.02585248

Appendix G-5. (continued)

Engraulis mordax Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.06266025
R Square	0.00392631
Adjusted R Square	-0.0262577
Standard Error	2003.7563
Observations	35

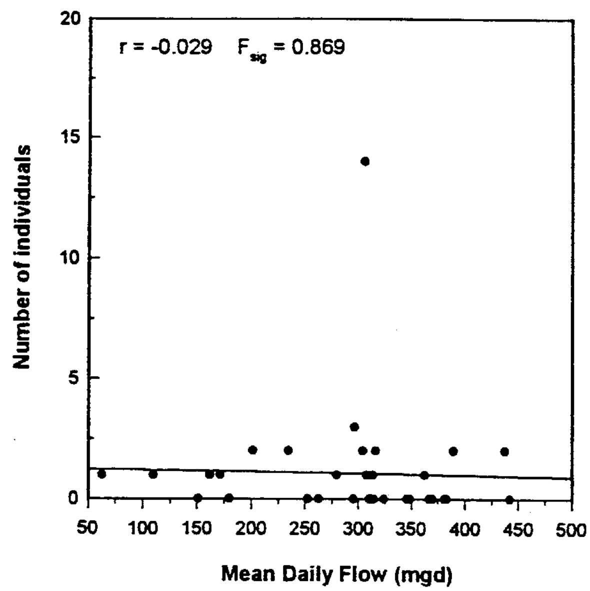
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	522271.7647	522271.7647	0.13007887	0.720648793
Residual	33	132496297	4015039.302		
Total	34	133018568.7			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	4.61984604	1189.613884	0.003883484	0.99692413	-2415.669717	2424.90941
x1	1.3954429	3.869088805	0.36066448	0.72058148	-6.476283699	9.2671695

Appendix G-5. (continued)

Paralichthys californicus Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.02883447
R Square	0.00083143
Adjusted R Square	-0.0294464
Standard Error	2.44776451
Observations	35

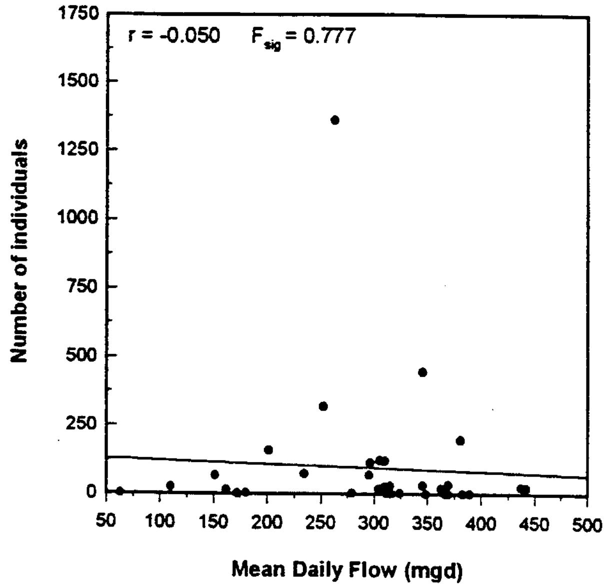
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	0.164527442	0.164527442	0.02745991	0.869395989
Residual	33	197.7211868	5.991551116		
Total	34	197.8857143			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.28798959	1.453217965	0.886301728	0.38168114	-1.668606931	4.24458612
x1	-0.0007832	0.004726432	-0.165710314	0.86936637	-0.010399225	0.00883279

Appendix G-5. (continued)

Hyperprosopon argenteum Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.04964403
R Square	0.00246453
Adjusted R Square	-0.0277638
Standard Error	243.933482
Observations	35

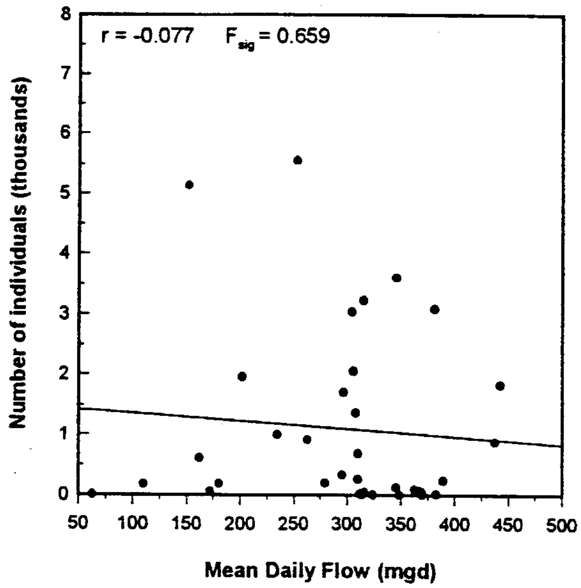
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	4851.348164	4851.348164	0.08153041	0.777018695
Residual	33	1963616.938	59503.54356		
Total	34	1968468.286			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	134.497338	144.8213323	0.928712201	0.35958508	-160.1441113	429.138788
x1	-0.1344916	0.471015515	-0.2855353	0.77696643	-1.092780586	0.82379747

Appendix G-5. (continued)

Seriphus politus Abundance vs. Mean Daily Flow Between Heat Treatments



Regression Statistics

Multiple R	0.07739947
R Square	0.00599068
Adjusted R Square	-0.0241308
Standard Error	1522.96207
Observations	35

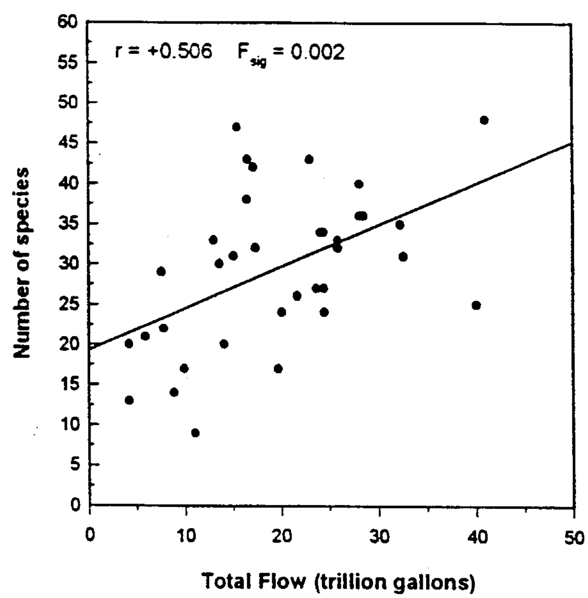
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1	461293.7913	461293.7913	0.19888381	0.658535748
Residual	33	76540644.61	2319413.473		
Total	34	77001938.4			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1485.93904	904.1702461	1.643428382	0.10951167	-353.6106107	3325.4887
x1	-1.3114526	2.940714651	-0.445963912	0.65845048	-7.294386298	4.67148108

Appendix G-6. Correlations of total circulating water flow between heat treatments with 20 parameters.

Number of fish species vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.506
R Square	0.256
Adjusted R Square	0.234
Standard Error	8.504
Observations	35.000

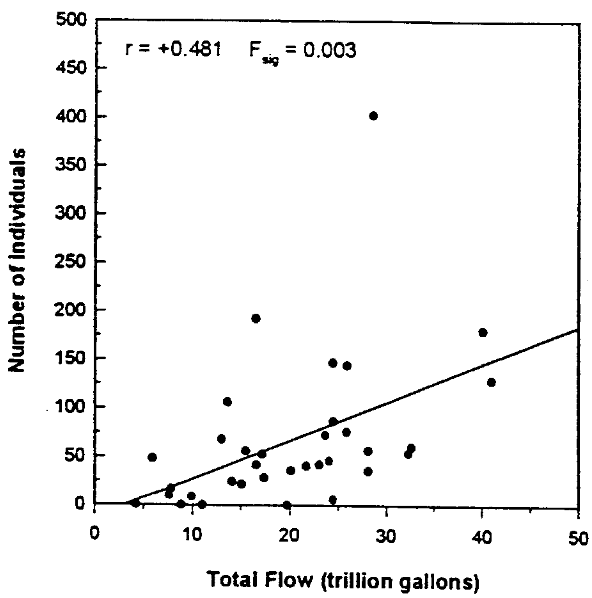
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	822.198	822.198	11.369	0.002
Residual	33.000	2386.545	72.320		
Total	34.000	3208.743			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	19.312	3.350	5.765	0.000	12.497	26.127
x1	0.001	0.000	3.372	0.002	0.000	0.001

Appendix G-6. (continued)

Paralabrax nebulifer Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.481
R Square	0.232
Adjusted R Square	0.208
Standard Error	69.103
Observations	35.000

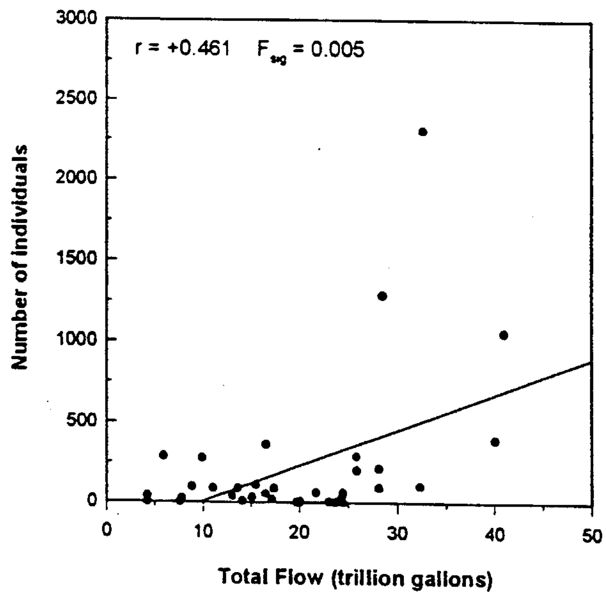
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	47502.501	47502.501	9.948	0.003
Residual	33.000	157581.899	4775.209		
Total	34.000	205084.400			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-11.946	27.220	-0.439	0.664	-67.326	43.434
x1	0.004	0.001	3.154	0.003	0.001	0.007

Appendix G-6. (continued)

Xenistius californiensis Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

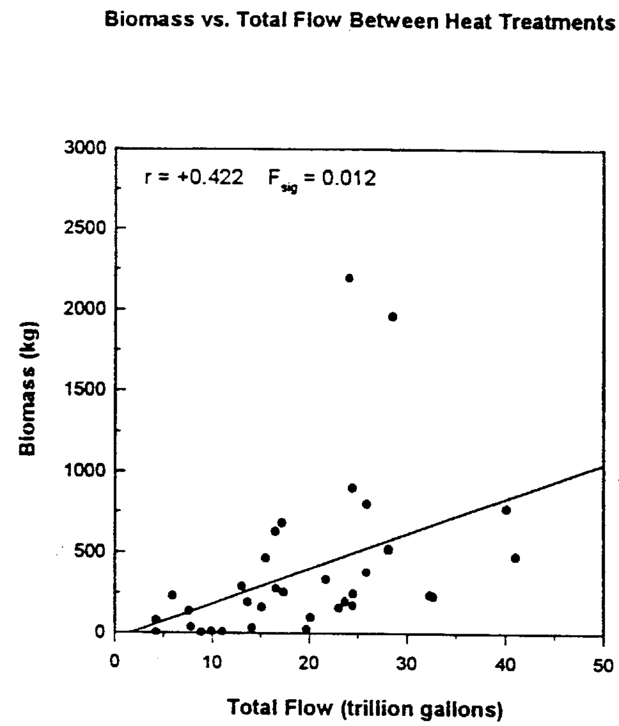
Multiple R	0.461
R Square	0.212
Adjusted R Square	0.189
Standard Error	410.796
Observations	35.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1501925.684	1501925.684	8.900	0.005
Residual	33.000	5568858.316	168753.282		
Total	34.000	7070784.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-214.041	161.816	-1.323	0.195	-543.258	115.176
x1	0.022	0.007	2.983	0.005	0.007	0.037

Appendix G-6. (continued)



Regression Statistics

Multiple R	0.422
R Square	0.178
Adjusted R Square	0.153
Standard Error	449.121
Observations	35.000

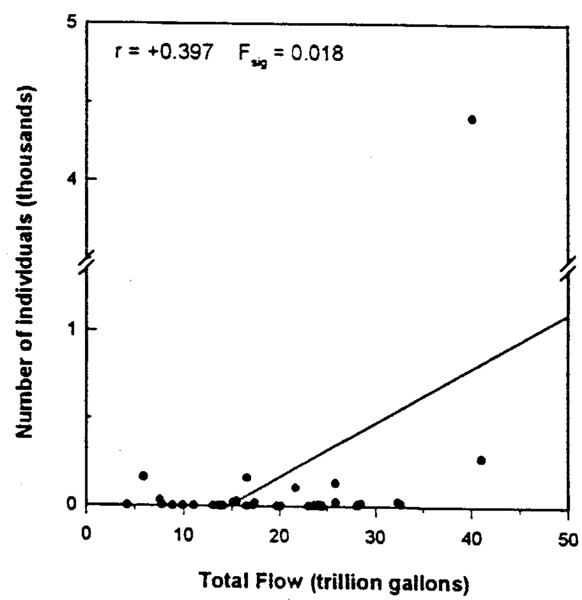
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1439853.824	1439853.824	7.138	0.012
Residual	33.000	6656425.115	201709.852		
Total	34.000	8096278.939			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-34.228	176.912	-0.193	0.848	-394.159	325.703
x1	0.022	0.008	2.672	0.011	0.005	0.038

Appendix G-6. (continued)

Umbrina roncador Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.397
R Square	0.158
Adjusted R Square	0.132
Standard Error	691.041
Observations	35.000

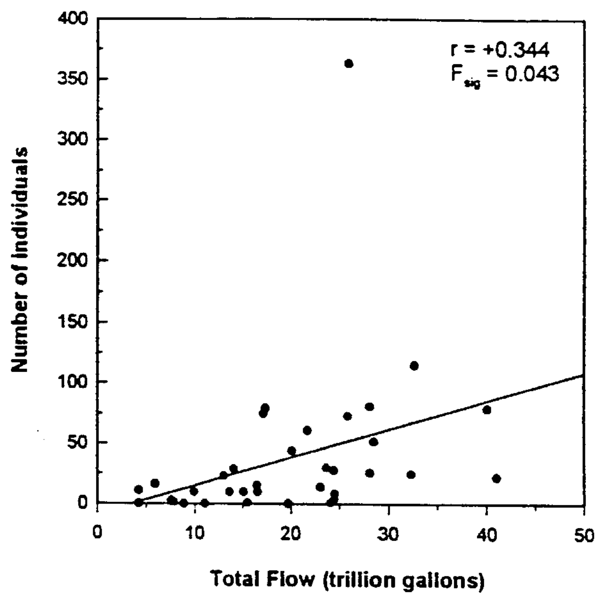
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	2953328.411	2953328.411	6.184	0.018
Residual	33.000	15758749.132	477537.852		
Total	34.000	18712077.543			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-455.133	272.206	-1.672	0.104	-1008.941	98.676
x1	0.031	0.013	2.487	0.018	0.006	0.057

Appendix G-6. (continued)

Paralabrax clathratus Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

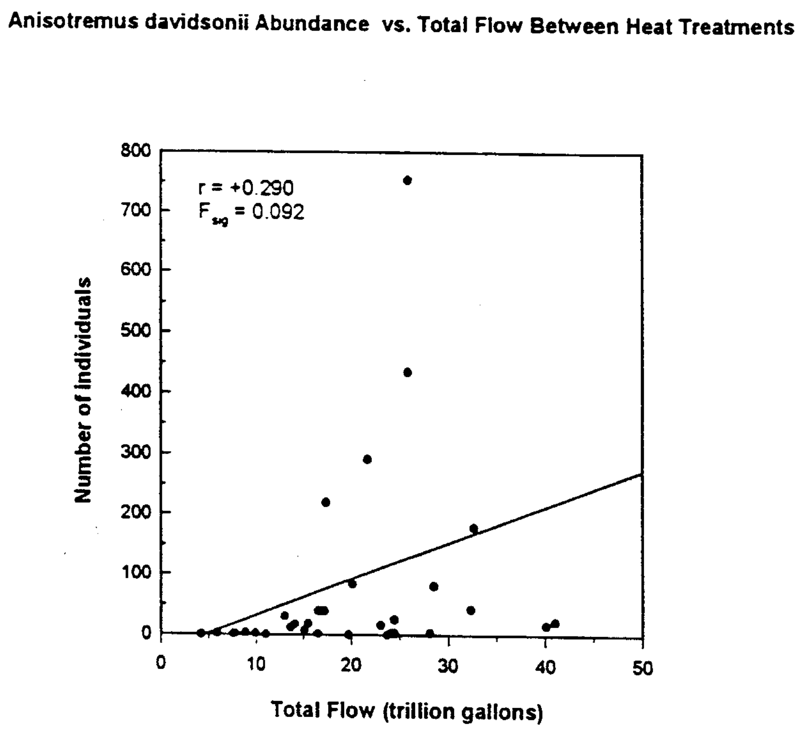
Multiple R	0.344
R Square	0.118
Adjusted R Square	0.092
Standard Error	61.056
Observations	35.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	16536.271	16536.271	4.436	0.043
Residual	33.000	123017.901	3727.815		
Total	34.000	139554.171			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-7.982	24.050	-0.332	0.742	-56.913	40.949
x1	0.002	0.001	2.106	0.043	0.000	0.005

Appendix G-6. (continued)



Regression Statistics

Multiple R	0.290
R Square	0.084
Adjusted R Square	0.056
Standard Error	191.047
Observations	35.000

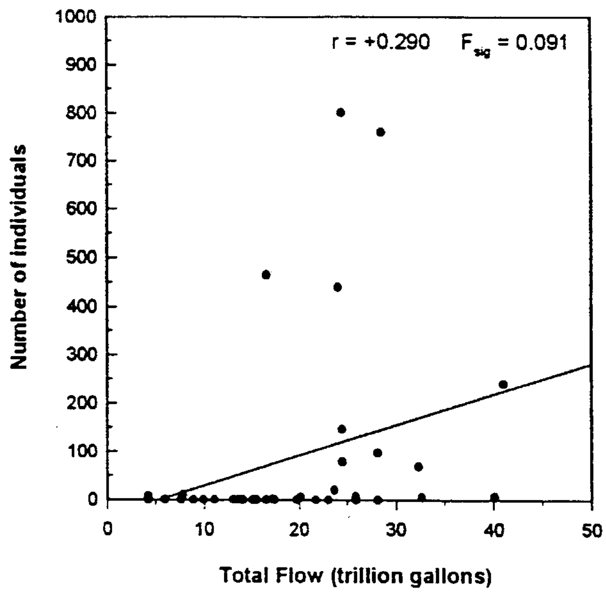
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	110187.139	110187.139	3.019	0.092
Residual	33.000	1204459.833	36498.783		
Total	34.000	1314646.971			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-27.276	75.255	-0.362	0.719	-180.383	125.831
x1	0.006	0.003	1.738	0.091	-0.001	0.013

Appendix G-6. (continued)

Scomber japonicus Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.290
R Square	0.084
Adjusted R Square	0.056
Standard Error	200.137
Observations	35.000

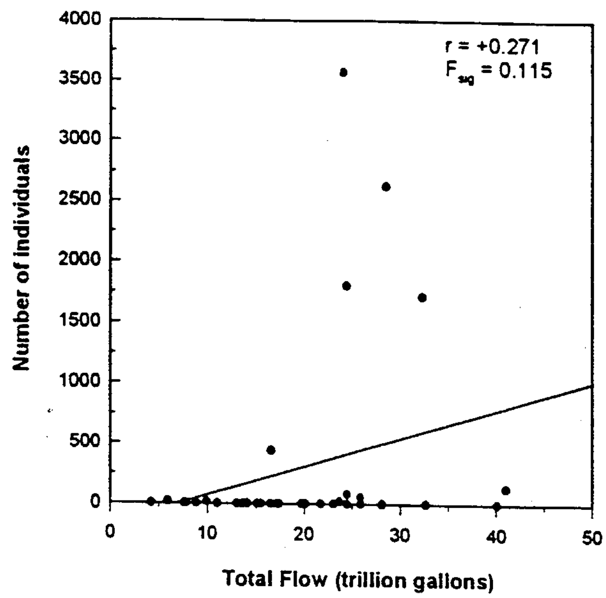
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	121111.059	121111.059	3.024	0.091
Residual	33.000	1321805.683	40054.718		
Total	34.000	1442916.743			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-33.307	78.835	-0.422	0.675	-193.699	127.085
x1	0.006	0.004	1.739	0.091	-0.001	0.014

Appendix G-6. (continued)

Sardinops sagax Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.271
R Square	0.073
Adjusted R Square	0.045
Standard Error	802.065
Observations	35.000

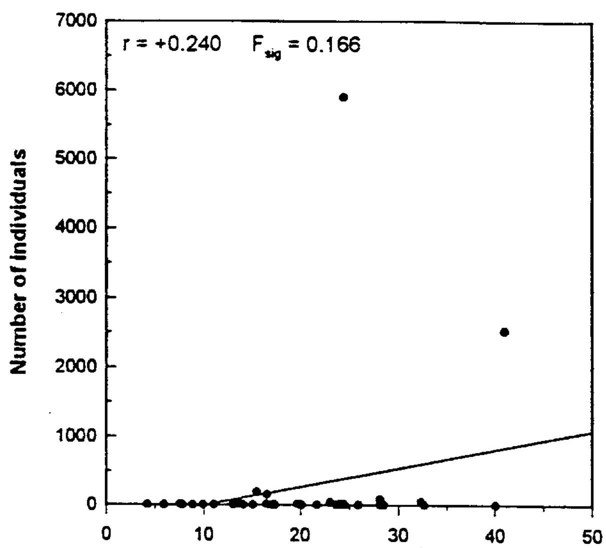
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1681958.909	1681958.909	2.615	0.115
Residual	33.000	21229199.091	643309.063		
Total	34.000	22911158.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-161.435	315.940	-0.511	0.613	-804.220	481.350
x1	0.024	0.015	1.617	0.115	-0.006	0.053

Appendix G-6. (continued)

Genyonemus lineatus Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.240
R Square	0.057
Adjusted R Square	0.029
Standard Error	1054.594
Observations	35.000

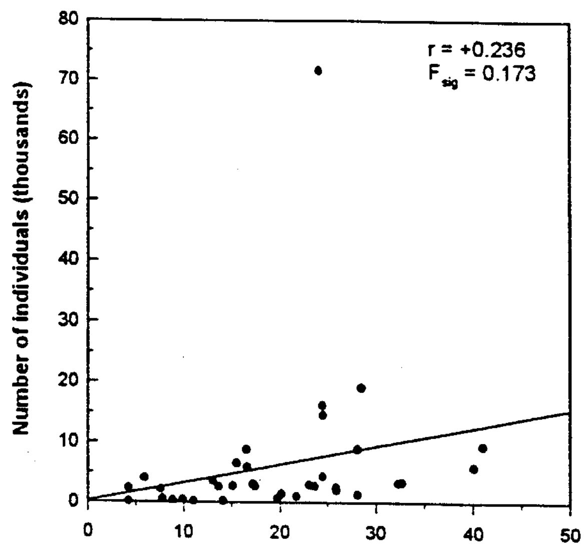
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	2234926.811	2234926.811	2.010	0.166
Residual	33.000	36701589.075	1112169.366		
Total	34.000	38936515.886			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-272.963	415.413	-0.657	0.516	-1118.127	572.202
x1	0.027	0.019	1.418	0.165	-0.012	0.066

Appendix G-6. (continued)

Total Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.236
R Square	0.056
Adjusted R Square	0.027
Standard Error	12093.636
Observations	35.000

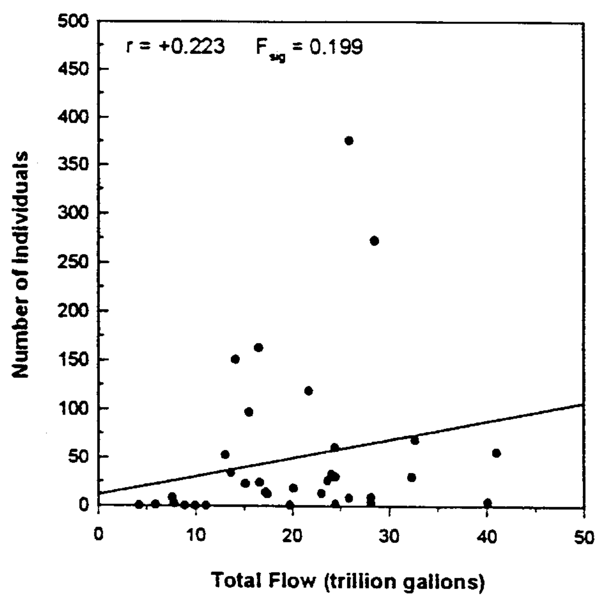
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	283655356.592	283655356.592	1.939	0.173
Residual	33.000	4826448849.008	146256025.728		
Total	34.000	5110104205.600			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	225.833	4763.776	0.047	0.962	-9466.151	9917.817
x1	0.305	0.219	1.393	0.173	-0.141	0.751

Appendix G-6. (continued)

Chromis punctipinnis Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.223
R Square	0.050
Adjusted R Square	0.021
Standard Error	80.723
Observations	35.000

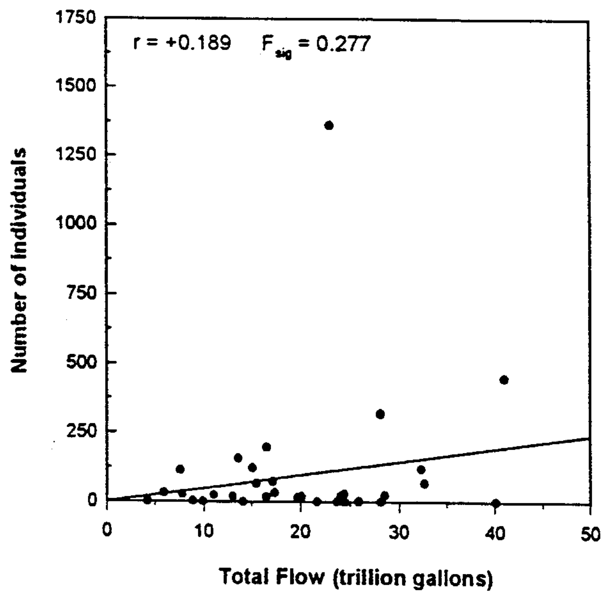
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	11208.801	11208.801	1.720	0.199
Residual	33.000	215036.170	6516.248		
Total	34.000	226244.971			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	11.303	31.798	0.355	0.724	-53.390	75.995
x1	0.002	0.001	1.312	0.198	-0.001	0.005

Appendix G-6. (continued)

Hyperprosopon argenteum Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.189
R Square	0.036
Adjusted R Square	0.007
Standard Error	239.829
Observations	35.000

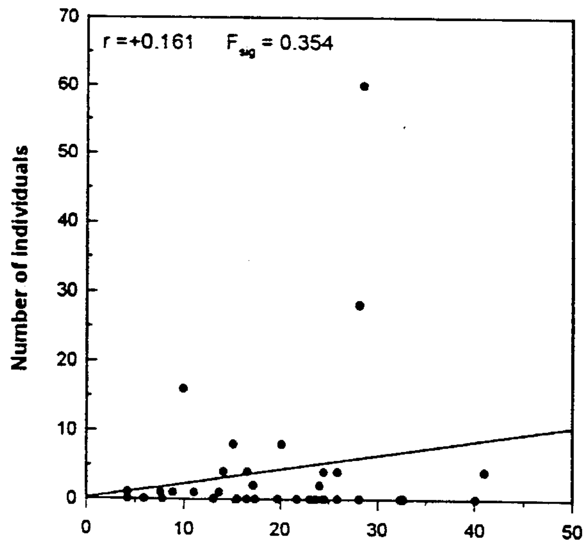
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	70376.420	70376.420	1.224	0.277
Residual	33.000	1898091.866	57517.935		
Total	34.000	1968468.286			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.469	94.470	0.005	0.996	-191.733	192.671
x1	0.005	0.004	1.106	0.276	-0.004	0.014

Appendix G-6. (continued)

Atractoscion nobilis Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.161
R Square	0.026
Adjusted R Square	-0.003
Standard Error	11.169
Observations	35.000

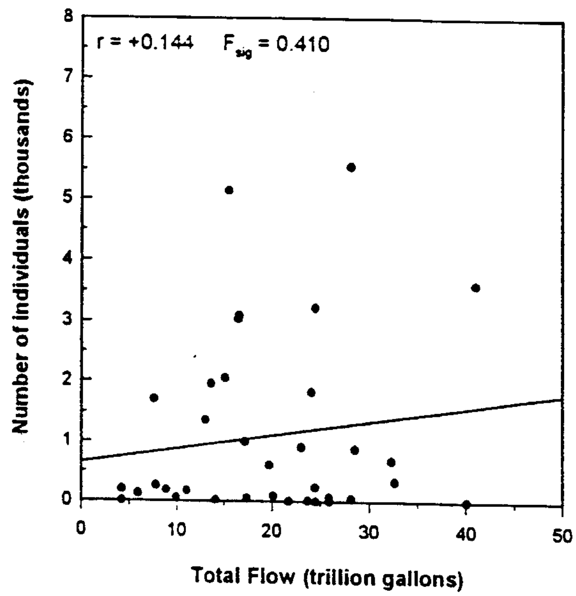
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	110.159	110.159	0.883	0.354
Residual	33.000	4116.527	124.743		
Total	34.000	4226.686			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.523	4.399	0.119	0.906	-8.428	9.474
x1	0.000	0.000	0.940	0.354	0.000	0.001

Appendix G-6. (continued)

Seriphus politus Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.144
R Square	0.021
Adjusted R Square	-0.009
Standard Error	1511.650
Observations	35.000

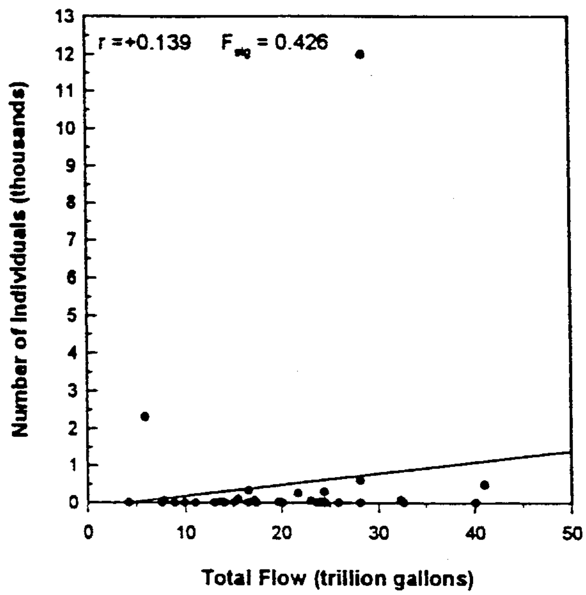
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	1594101.668	1594101.668	0.698	0.410
Residual	33.000	75407836.732	2285085.962		
Total	34.000	77001938.400			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	650.178	595.451	1.092	0.283	-561.276	1861.633
x1	0.023	0.027	0.835	0.409	-0.033	0.079

Appendix G-6. (continued)

Atherinopsis californiensis Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.139
R Square	0.019
Adjusted R Square	-0.010
Standard Error	2052.310
Observations	35.000

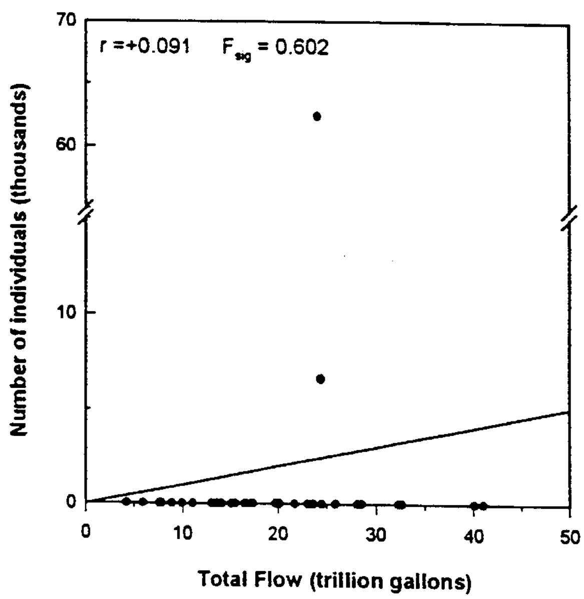
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	2735607.270	2735607.270	0.649	0.426
Residual	33.000	138995257.301	4211977.494		
Total	34.000	141730864.571			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-107.906	808.421	-0.133	0.895	-1752.652	1536.840
x1	0.030	0.037	0.806	0.426	-0.046	0.106

Appendix G-6. (continued)

Trachurus symmetricus Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.091
R Square	0.008
Adjusted R Square	-0.022
Standard Error	10691.191
Observations	35.000

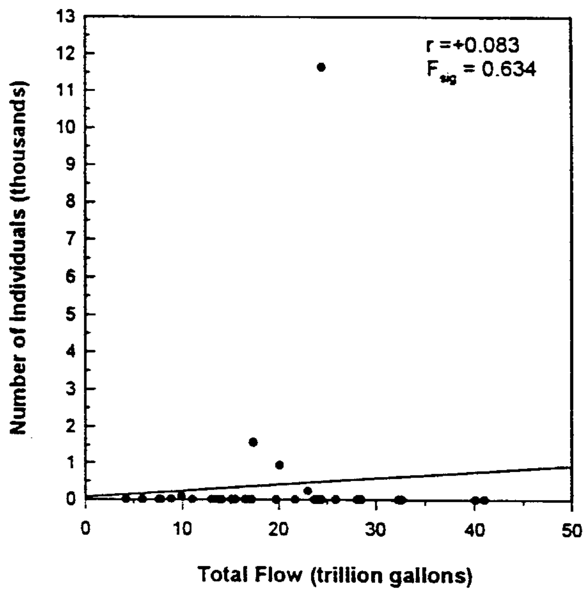
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	31741695.843	31741695.843	0.278	0.602
Residual	33.000	3771951854.157	114301571.338		
Total	34.000	3803693550.000			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-27.555	4211.343	-0.007	0.995	-8595.603	8540.493
x1	0.102	0.194	0.527	0.602	-0.292	0.497

Appendix G-6. (continued)

Engraulis mordax Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

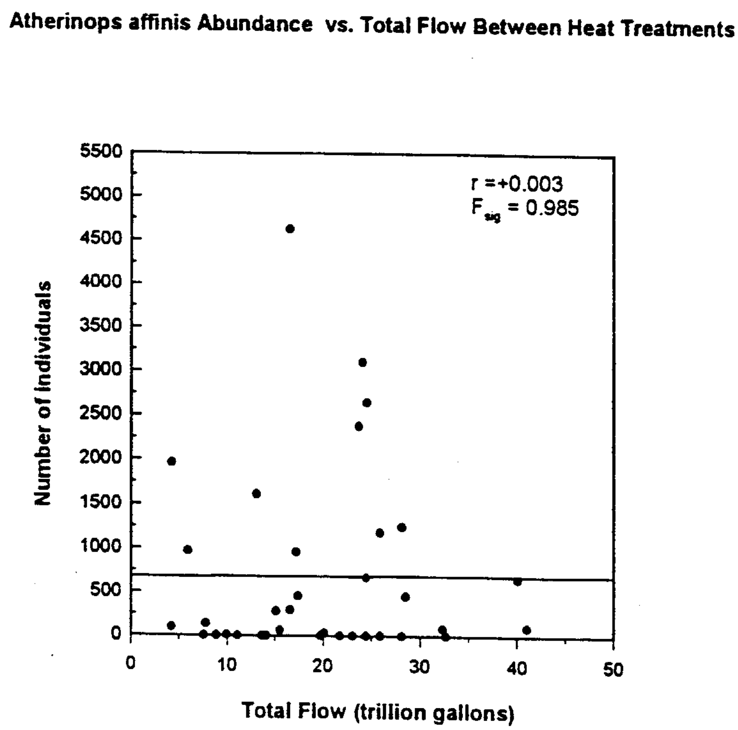
Multiple R	0.083
R Square	0.007
Adjusted R Square	-0.023
Standard Error	2000.720
Observations	35.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	923449.597	923449.597	0.231	0.634
Residual	33.000	132095119.146	4002882.398		
Total	34.000	133018568.743			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	74.006	788.099	0.094	0.926	-1529.395	1677.407
x1	0.017	0.036	0.480	0.634	-0.056	0.091

Appendix G-6. (continued)



Regression Statistics

Multiple R	0.003
R Square	0.000
Adjusted R Square	-0.030
Standard Error	1101.391
Observations	35.000

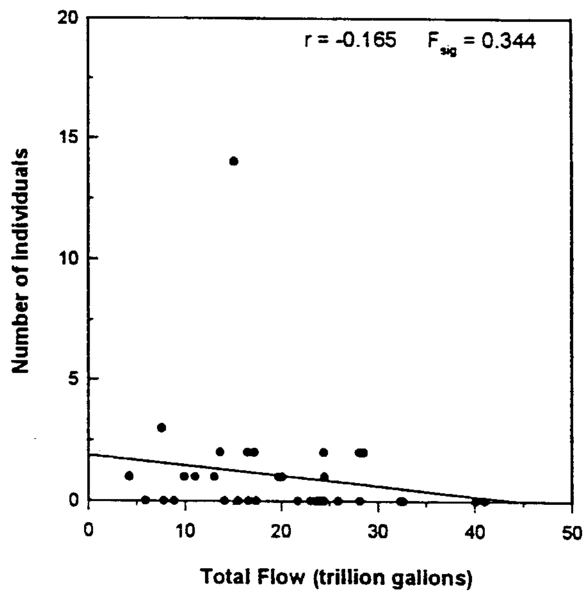
Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	459.497	459.497	0.000	0.985
Residual	33.000	40031045.189	1213061.975		
Total	34.000	40031504.686			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	678.916	433.846	1.565	0.127	-203.752	1561.584
x1	0.000	0.020	0.019	0.985	-0.040	0.041

Appendix G-6. (continued)

Paralichthys californicus Abundance vs. Total Flow Between Heat Treatments



Regression Statistics

Multiple R	0.165
R Square	0.027
Adjusted R Square	-0.002
Standard Error	2.415
Observations	35.000

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	1.000	5.380	5.380	0.922	0.344
Residual	33.000	192.506	5.834		
Total	34.000	197.886			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.882	0.951	1.979	0.056	-0.053	3.818
x1	0.000	0.000	-0.960	0.344	0.000	0.000

APPENDIX H
FISH TAKEN IN SURVEYS IN AND NEAR ALAMITOS BAY

Appendix H. Fish taken in surveys in and near Alamitos Bay.

		Habitat Preference*								Survey Occurrences			
Species	Common name	Pelagic	Soft Bottom	Rocky Hard Bottom	Kelp Bed	Bay	Nearshore	Offshore	Eelgrass/Intertidal	1973 Colorado Lagoon	1981 316(b) Trawls	1981 316(b) Impingements	1986-1994 Trawls
Engraulis mordax	northern anchovy	P					N	O		X	X	X	X
Genyonemus lineatus	white croaker	P	S				N	O		X	X	X	X
Seriphus politus	queenfish	P	s				N			X	X	X	X
Cymatogaster aggregata	shiner perch	P	S			B	N	O		X	X	X	X
Atherinops affinis	topsmelt	P	s		K	B	N			X	X	X	
Anchoa delicatissima	slough anchovy	P				B	N			X	X	X	
Peprilus simillimus	Pacific butterfish	P						O			X	X	X
Phanerodon furcatus	white seaperch	p	S	r			N			X	X	X	X
Hyperprosopon argenteum	walleye surfperch	P	s				N				X	X	X
Symphurus atricauda	California tonguefish		S				N	O			X	X	X
Citharichthys stigmaeus	speckled sanddab		S				N				X	X	X
Embiotoca jacksoni	black surfperch	p	s	R			N			X	X	X	X
Paralichthys californicus	California halibut		S			B	N				X	X	X
Pleuronichthys ritteri	spotted turbot		S				N				X	X	X
Fundulus parvipinnis	California killifish								F	X			
Anchoa compressa	deepbody anchovy	P				B	N			X	X	X	X
Leuresthes tenuis	California grunion	P	S				N			X	X	X	
Leptocottus armatus	staghorn sculpin		S			B	n			X	X	X	X
Hypsopsetta guttulata	diamond turbot		S			B	N			X	X	X	X
Ophidion scrippsae	basketweave cusk-eel	p	S				N				X	X	X
Synodus lucioceps	California lizardfish		S				N				X		X
Pleuronichthys verticalis	hornyhead turbot		S				N	O			X	X	X
Menticirrhus undulatus	California corbina		S				N			X	X	X	X
Urolophus halleri	round stingray		S			B	N			X	X	X	X
Paralabrax nebulifer	barred sand bass	p	S	r			N			X	X	X	X
Acanthogobius flavimanus	yellowfin goby		S			B					X		X
Myliobatis californica	bat ray		S				N			X	X	X	X
Porichthys myriaster	specklefin midshipman	p	S				N				X	X	X
Mugil cephalus	striped mullet	p	S				N			X		X	
Sardinops sagax	Pacific sardine	P					N	O					X
Platyrhinoidis triseriata	thornback		S				N				X	X	X
Damalichthys vacca	pile perch	p		R			N			X	X	X	X
Torpedo californica	Pacific electric ray	P	S	R	K		N	O			X	X	X
Umbrina roncador	yellowfin croaker	p	S				N					X	X
Lepidogobius lepidus	bay goby		S				N	O			X		X
Rhinobatos productus	shovelnose guitarfish		S				N				X		X
Syngnathus exilis	barcheek pipefish		S			B	n						X
Porichthys notatus	plainfin midshipman	P	S				N	O			X	X	X
Syngnathus californiensis	kelp pipefish				K		N					X	X
Quietula y-cauda	shadow goby		S				N			X			
Dorosoma petenense	threadfin shad								F	X			
Xenistius californiensis	salema	P		r	K		N					X	X
Atherinopsis californiensis	jacksmelt	P					N				X	X	X
Atractoscion nobilis	white seabass	P	s	R	K		N				X	X	X
Paralabrax maculatofasciatus	spotted sand bass	p	S			B	n		E	X		X	
Heterostichus rostratus	giant kelpfish				K		N					X	X
Scorpaena guttata	California scorpionfish		S	R			N				X		X
Parophrys vetulus	English sole		S				N	O				X	X
Clevelandia ios	arrow goby		S			B			I	X	X	X	X
Cheilotrema saturnum	black croaker	p		R			N					X	X
Trachurus symmetricus	jack mackerel	P					N	O				X	X

Appendix H. Fish taken in surveys in and near Alamitos Bay.

		Habitat Preference*								Survey Occurrences			
Species	Common name	Pelagic	Soft Bottom	Rocky Hard Bottom	Kelp Bed	Bay	Nearshore	Offshore	Eelgrass/Intertidal	1973 Colorado Lagoon	1981 316(b) Trawls	1981 316(b) Impingements	1986-1994 Trawls
Tilapia mossambica	Mozambique tilapia								F			X	X
Roncador stearnsii	spotfin croaker		S	r		b	N			X		X	
Raja inornata	California skate		S				N						X
Raja binoculata	big skate		S				N	O					X
Citharichthys xanthostigma	longfin sanddab		S				N	O					X
Chromis punctipinnis	blacksmith	P	s	R	K		N					X	X
Anisotremus davidsonii	sargo	P		R			N					X	X
Syngnathus leptorhynchus	bay pipefish					B			E	X	X	X	
Sarda chiliensis	Pacific bonito	P					N	O		X		X	
Ilypnus gilberti	cheekspot goby		S			B				X	X		
Girella nigricans	opaleye	p		R	K		N			X			
Amphistichus argenteus	barred surfperch	p	S				N				X		
Hippoglossina stomata	bigmouth sole		S					O			X		
Hypsoblennius gilberti	rockpool blenny			R					I		X	X	
Strongylura exilis	California needlefish		S			B	N				X	X	
Xystreurys liolepis	fantail sole		S				N				X		
Gillichthys mirabilis	longjaw mudsucker		S			B					X	X	
Pleuronichthys decurrens	curlfin sole		S				N	O				X	
Paralabrax clathratus	kelp bass	p		R	K		N					X	
Pleuronichthys coenosus	c-o sole		S				N					X	
Gibbonsia elegans	spotted kelpfish				K		N					X	
Merluccius productus	Pacific hake	P					n	O				X	
Gibbonsia metzi	striped kelpfish				K		N					X	
Neoclinus uninotatus	onespot fringehead			R			N					X	
Rhacochilus toxotes	rubberlip surfperch	P	R	K			N		I			X	
Sebastes rastrelliger	grass rockfish	p		R			N					X	
Sebastes serranoides	olive rockfish	P		R	K		N					X	
Sebastes atrovirens	kelp rockfish	P		R	K		N					X	
Sebastes auriculatus	brown rockfish			R			N					X	
Scomber japonicus	chub mackerel	P					N	O				X	
Sphyraena argentea	Pacific barracuda	P					N	O				X	
Hydrolagus colliei	spotted ratfish	P						O				X	

Habitats:

(upper case = major habitat;lower case = minor habitat)

P = Pelagic (water column)	N = Nearshore
S = Soft Bottom	O = Offshore
R = Rocky Hard Bottom	F = Freshwater
K = Kelp Bed	E = Eelgrass
B = Bay	I = Intertidal

*Source: Modified from M.J. Allen, So. Calif. Coastal Water Res. Proj. Westminster, CA, pers. comm. 1 Dec. 1995.

APPENDIX I
FISH TAKEN IN LOS ANGELES AND LONG BEACH INNER HARBOR AREAS

Appendix I. Fish taken in Los Angeles and Long Beach Inner Harbor areas.

Species	Common name	Harbor NPDES 1978-1994	LBGS NPDES 1980-1994	LA-LB Inner Harbor 1971-1979
Acanthogobius flavimanus	yellowfin goby	X	X	
Anchoa compressa	deepbody anchovy	X	X	X
Anchoa delicatissima	slough anchovy	X		X
Anisotremus davidsonii	sargo			X
Artedius lateralis	smoothhead sculpin			X
Atherinops affinis	topsmelt			X
Atractoscion nobilis	white seabass			X
Cheilotrema saturnum	black croaker			X
Chilara taylori	spotted cusk-eel			X
Citharichthys sordidus	Pacific sanddab			X
Citharichthys stigmaeus	speckled sanddab	X	X	X
Clevelandia ios	arrow goby	X		X
Cymatogaster aggregata	shiner perch	X	X	X
Cyprinus carpio	carp			X
Damalichthys vacca	pile perch	X	X	X
Embiotoca jacksoni	black perch	X	X	X
Engraulis mordax	northern anchovy	X	X	X
Genyonemus lineatus	white croaker	X	X	X
Gibbonsia elegans	spotted kelpfish		X	
Gobiidae, unid.	goby, unid.	X		X
Heterostichus rostratus	giant kelpfish	X	X	X
Hippoglossina stomata	bigmouth sole			X
Hyperprosopon argenteum	walleye surfperch		X	X
Hypsoblennius gilberti	rockpool blenny		X	
Hypsopsetta guttulata	diamond turbot		X	
Icelinus quadriseriatus	yellowchin sculpin		X	
Ilypnus gilberti	cheekspot goby	X		X
Lepidogobius lepidus	bay goby	X	X	X
Leptocottus armatus	staghorn sculpin	X	X	X
Leuresthes tenuis	California grunion			X
Mustelus henlei	brown smoothhound		X	X
Myliobatis californica	bat ray			X
Neoclinus uninotatus	onespot fringehead			X
Odontopyxis trispinosa	pygmy poacher			X
Ophidion scrippsae	basketweave cusk-eel		X	X
Paralabrax clathratus	kelp bass		X	
Paralabrax nebulifer	barred sand bass	X	X	X
Paralichthys californicus	California halibut	X	X	X
Parophrys vetulus	English sole			X
Peprilus simillimus	Pacific pompano	X	X	X
Phanerodon furcatus	white seaperch	X	X	X
Platyrhinoidis triseriata	thornback		X	

Appendix I. Fish taken in Los Angeles and Long Beach Inner Harbor areas.

Species	Common name	Harbor NPDES 1978-1994	LBGS NPDES 1980-1994	LA-LB Inner Harbor 1971-1979
Pleuronichthys decurrens	curlfin turbot			X
Pleuronichthys ritteri	spotted turbot	X	X	X
Pleuronichthys verticalis	hornyhead turbot		X	X
Porichthys myriaster	specklefin midshipma	X	X	X
Porichthys notatus	plainfin midshipman	X	X	X
Rhacochilus toxotes	rubberlip surfperch		X	X
Rhinobatos productus	shovelnose guitarfish		X	X
Sardinops sagax	Pacific sardine	X	X	
Scomber japonicus	chub mackerel		X	
Scorpaena guttata	California scorpionfish		X	X
Sebastes auriculatus	brown rockfish		X	X
Sebastes dalli	calico rockfish		X	X
Sebastes miniatus	vermillion rockfish			X
Sebastes mystinus	blue rockfish			X
Sebastes paucispinis	bocaccio			X
Sebastes rastrelliger	grass rockfish		X	
Sebastes saxicola	stripetail rockfish			X
Sebastes semicinctus	halfbanded rockfish			X
Sebastes serraniodes	olive rockfish			X
Sebastes sp.	unid. rockfish		X	X
Seriphus politus	queenfish	X	X	X
Squalus acanthias	spiny dogfish			X
Symphurus atricauda	California tonguefish	X	X	X
Syngnathus leptorhynchus	bay pipefish	X		
Syngnathus sp.	unid. pipefish			X
Synodus lucioceps	California lizardfish	X	X	X
Torpedo californica	Pacific electric ray	X		
Trachurus symmetricus	jack mackerel	X		X
Tridentiger trigonocephalus	chameleon goby	X		
Urolophus halleri	round stingray	X	X	X
Xenistius californiensis	salema		X	
Xystreurys liolepis	fantail sole	X	X	X

Harbor Trawls = 3 stations in Los Angeles Inner Harbor (LCMR-IRC 1979; IRC 1981c; OC 1986, 1988; MBC 1990b, 1991b, 1992c, 1993c, 1994d)

Long Beach Trawls = 3 stations in Long Beach Back Channel (MBC 1981, 1986, 1988b, 1990c, 1991c, 1992d, 1993d. 1994e)

LA/LB Inner Harbor = Soule and Oguri 1980